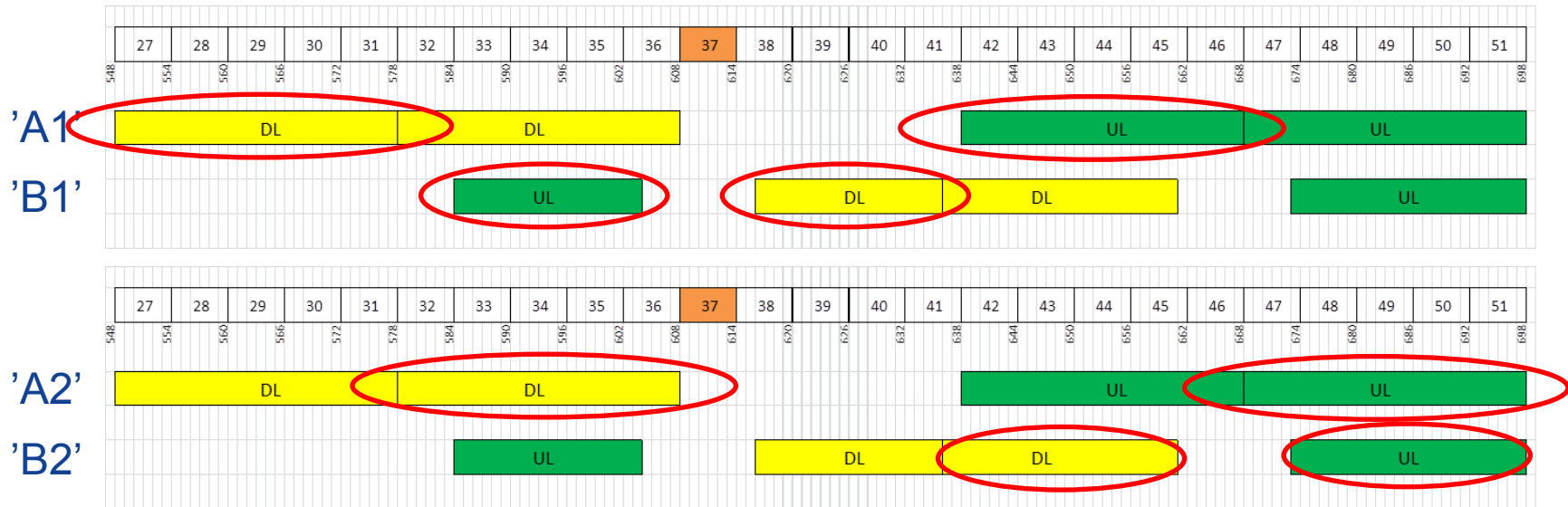


Mobile antennas reaching the 600 MHz band, comparison of different band proposals

Antti Karilainen
14 March 2013

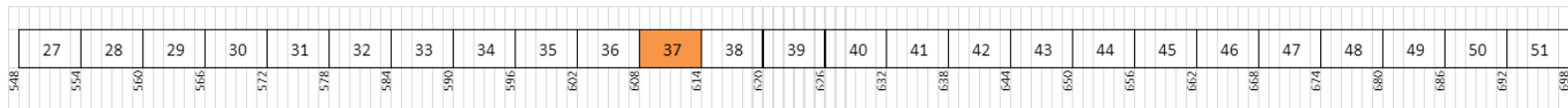
600 MHz band plan proposals: six cases (1/2)



Band	UL [MHz]	DL [MHz]	BW [MHz]	BW [%]
A1	638-668	548-578	30	19.7
A2	668-698	578-608	30	18.8
B1	584-604	616-636	20	8.5
B2	673-698	636-661	25	9.3
B3	663-698	618-653	35	12.2
B4	673-698	588-608, 618-663	25/75	17.1

An unfortunate choice of naming, not to be mixed up with the 3GPP band numbers!

600 MHz band plan proposals: six cases (2/2)



'B3'

DL

UL

'B4'

DL

DL

UL

We focus on 'A2', 'B2', 'B3', and 'B4' in these slides!

Band	UL [MHz]	DL [MHz]	BW [MHz]	BW [%]
A1	638-668	548-578	30	19.7
A2	668-698	578-608	30	18.8
B1	584-604	616-636	20	8.5
B2	673-698	636-661	25	9.3
B3	663-698	618-653	35	12.2
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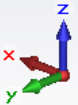
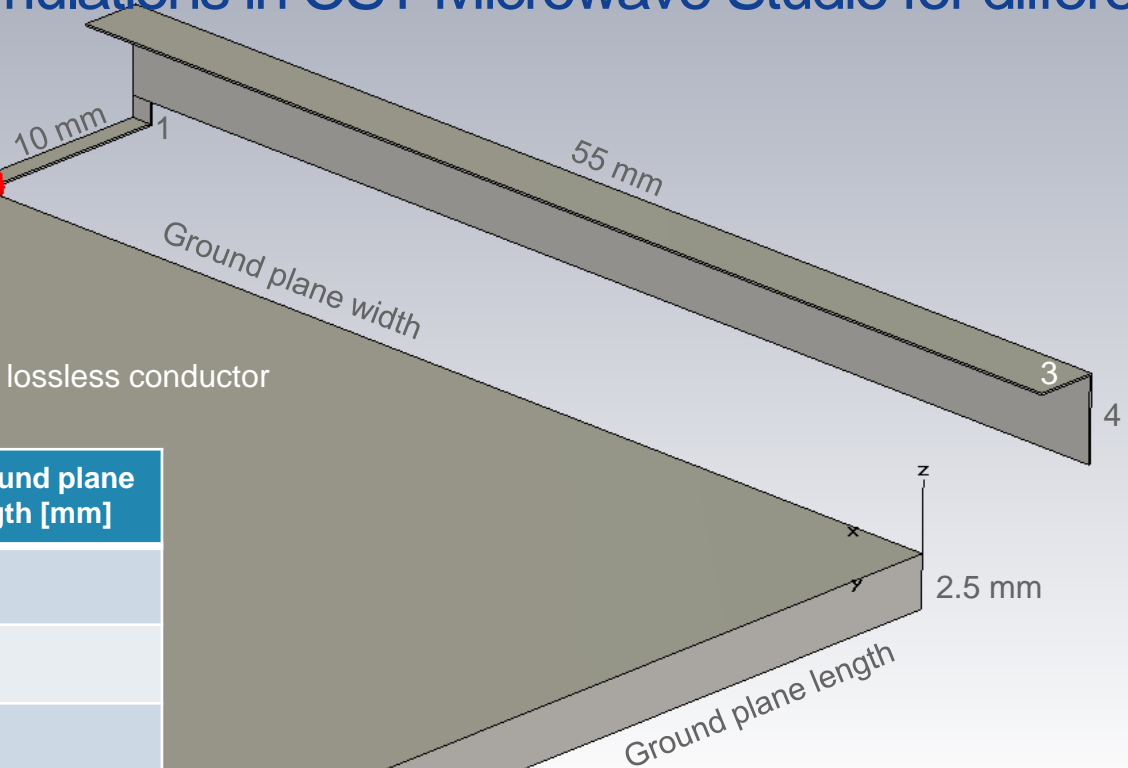
Antenna simulations

No MIMO antenna considered (Alternatively, perfect isolation between the antennas). Also, the envelope correlation between the antennas not considered.

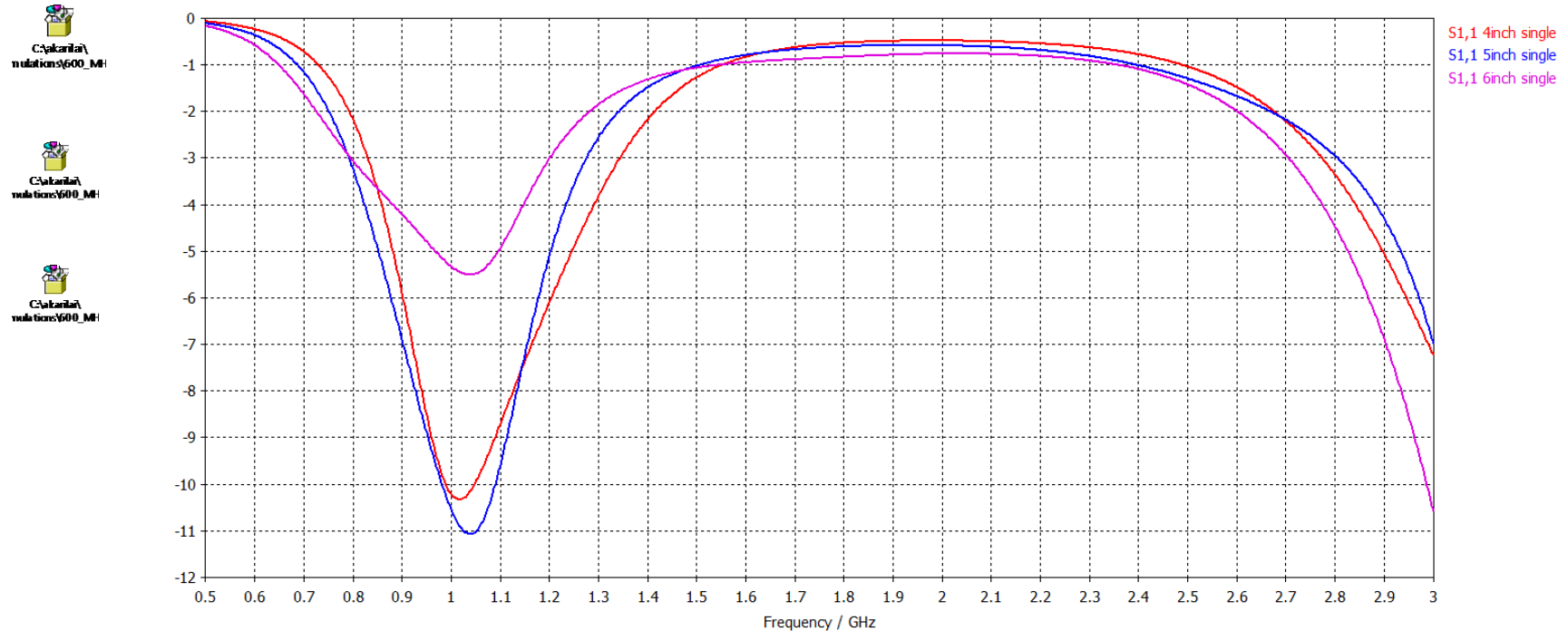
Lossless antenna simulations in CST Microwave Studio for different ground plane sizes

Antenna & ground plane modeled as lossless conductor

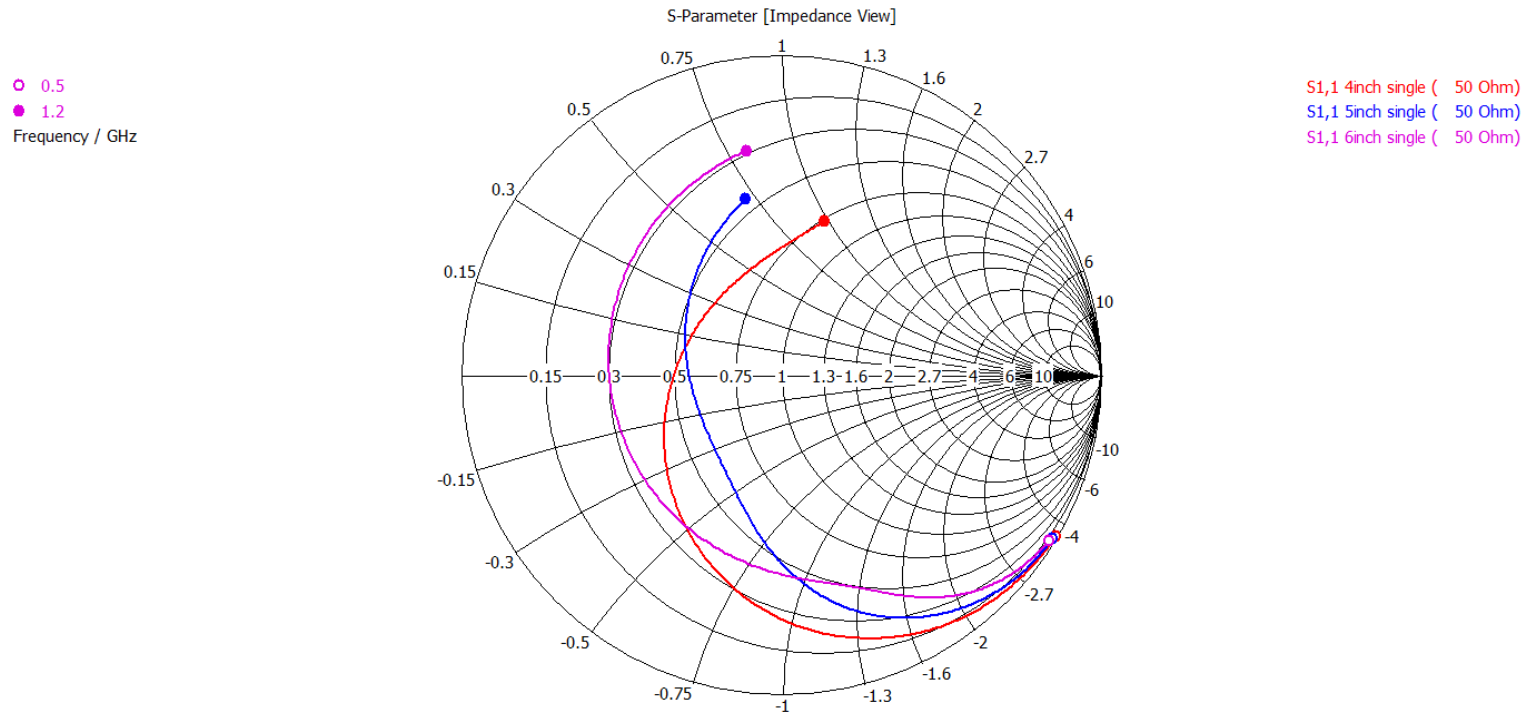
Device screen size [inch]	Ground plane width [mm]	Ground plane length [mm]
4	55	90
5	68	112
6	82	134



S parameters from the simulations

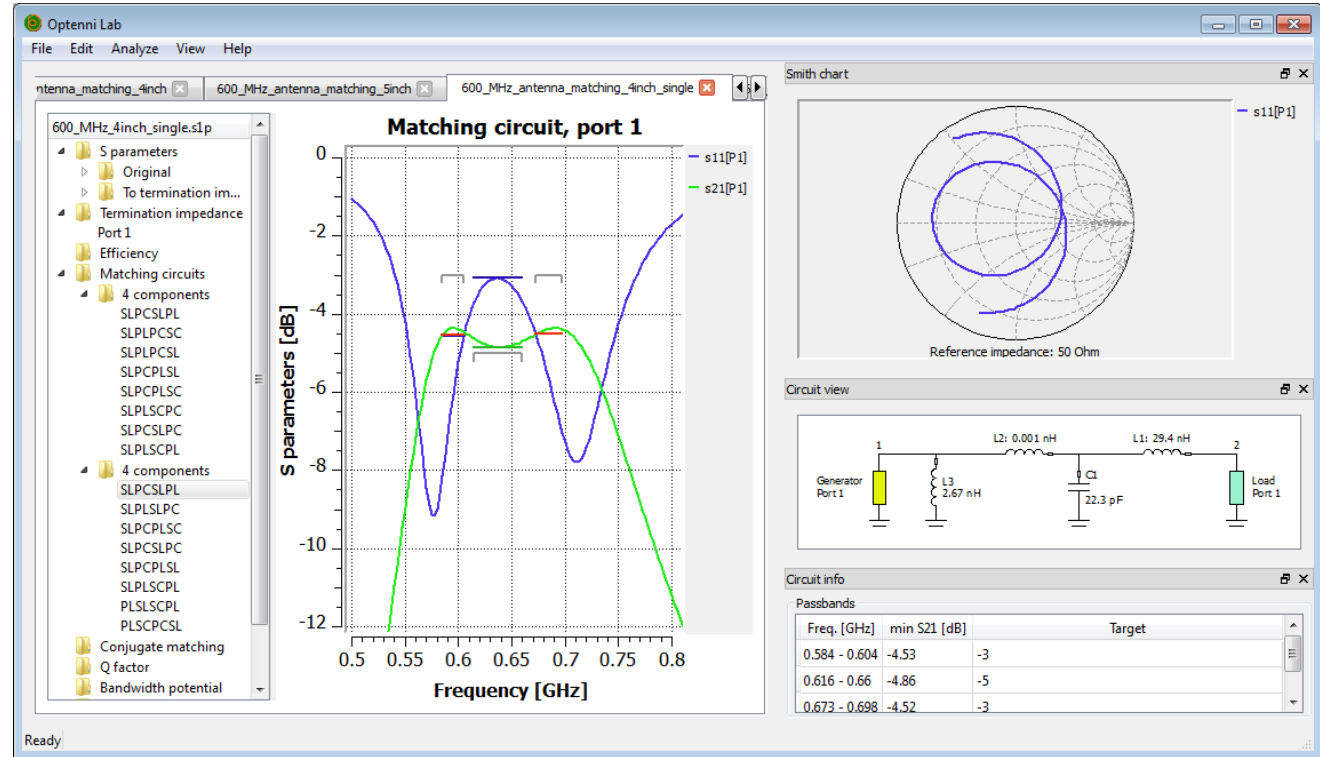


Impedances from the simulations



Optenni Lab software used for matching-circuit generation

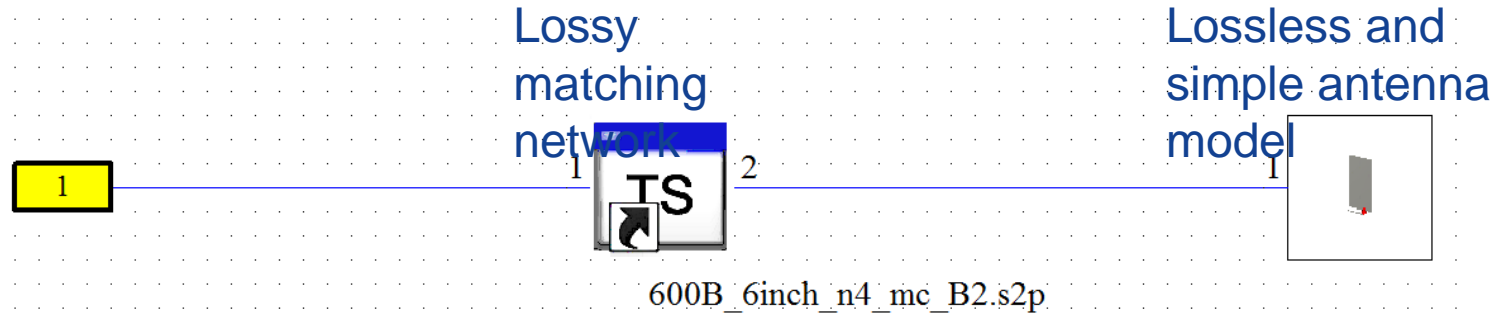
- Four L/C matching components allowed
- Optimize for the maximum power accepted by the antenna
- Best topology chosen for total efficiency comparison in each matching scenario
- When creating a B17-optimized antenna, use the L1 series inductor from the B17 matching circuit in the 600-MHz-band optimized matching circuit



Emphasis on Tx frequencies and only the 600-MHz band considered: 'A2' and 'B2'

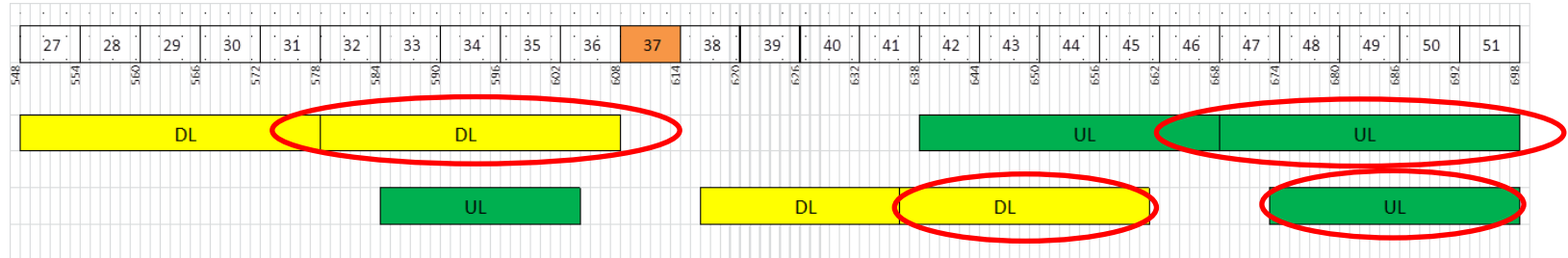
Optimize for 2 dB worse efficiency for Rx frequencies in Optenni Lab

Total efficiency calculations for 600 MHz band optimized antennas

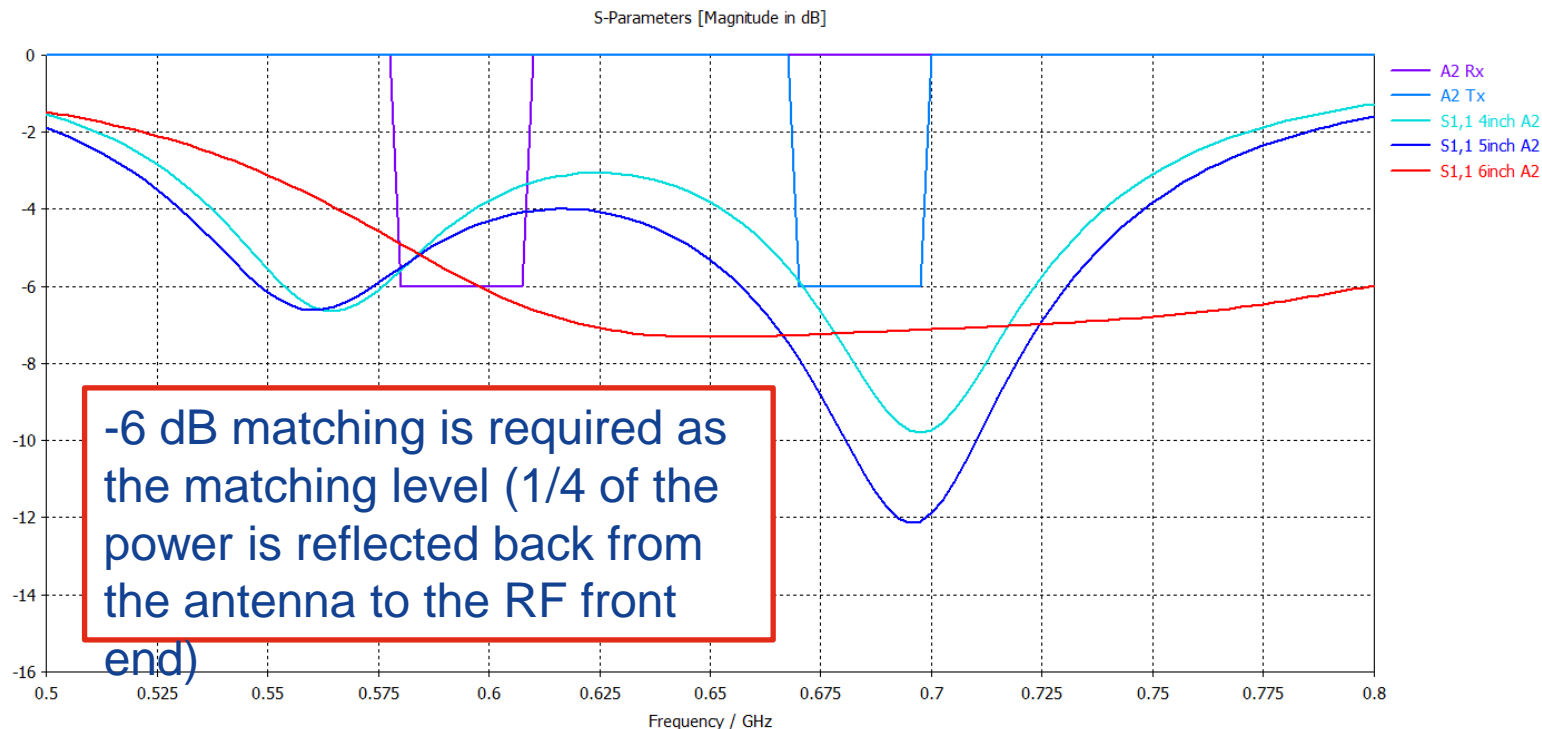


A2

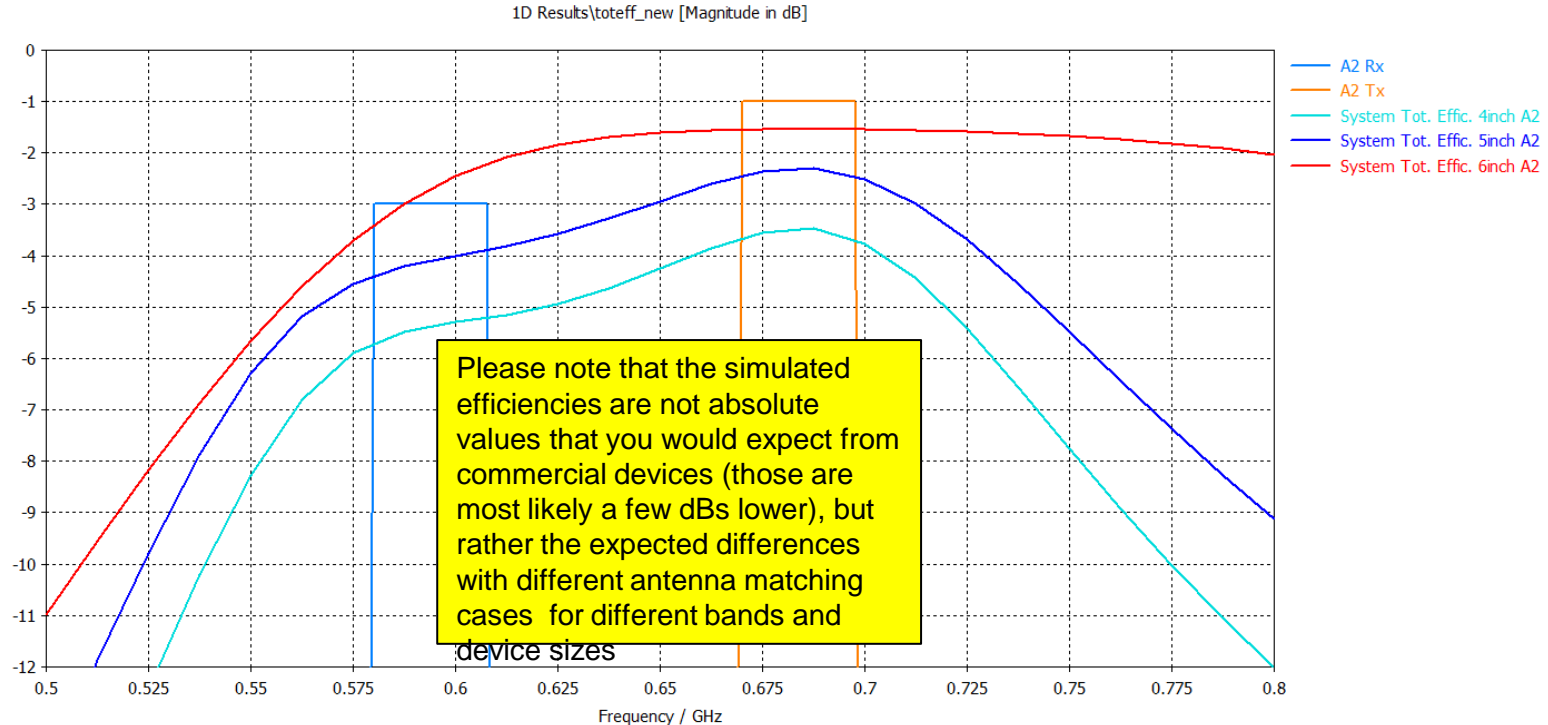
B2



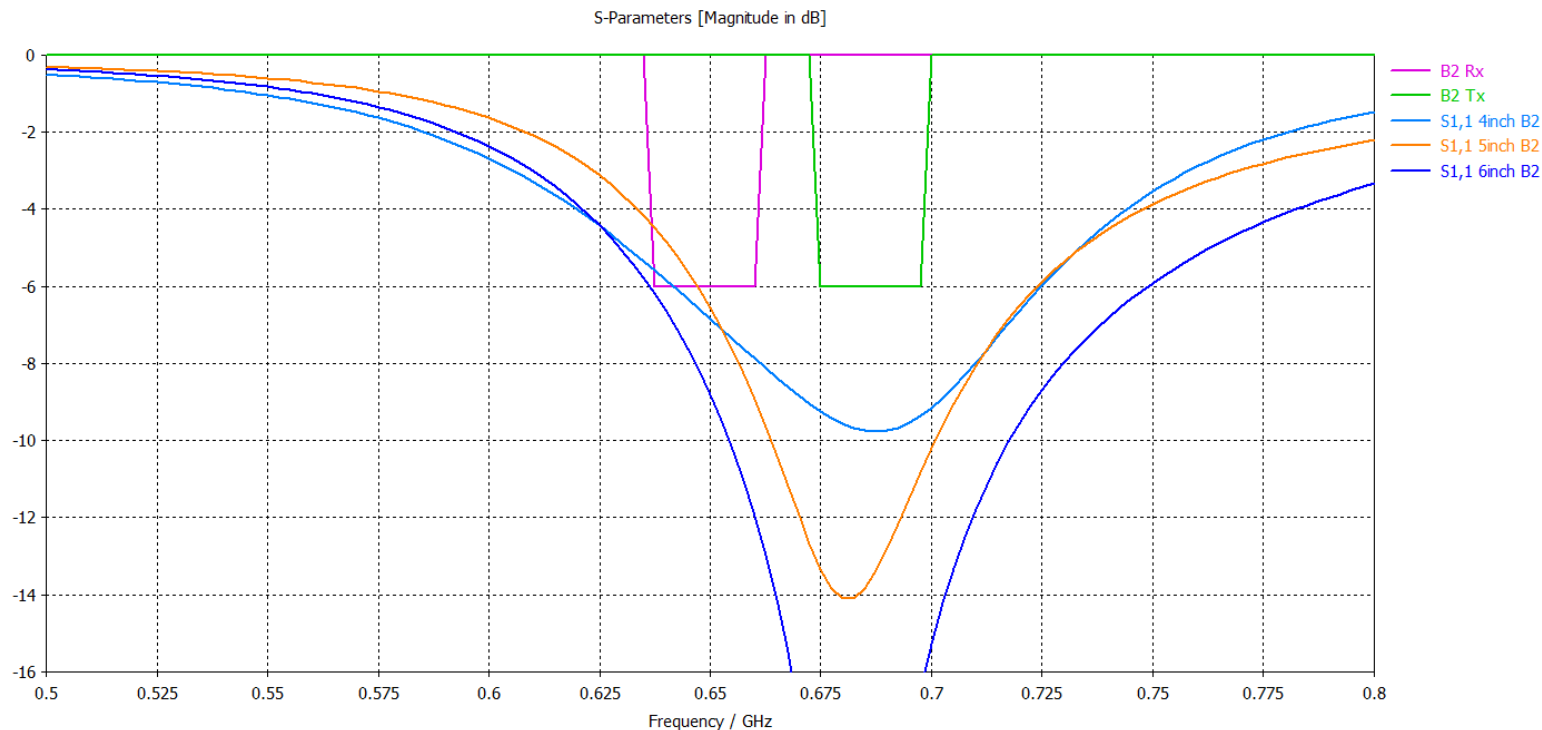
Matching levels for band combination A2



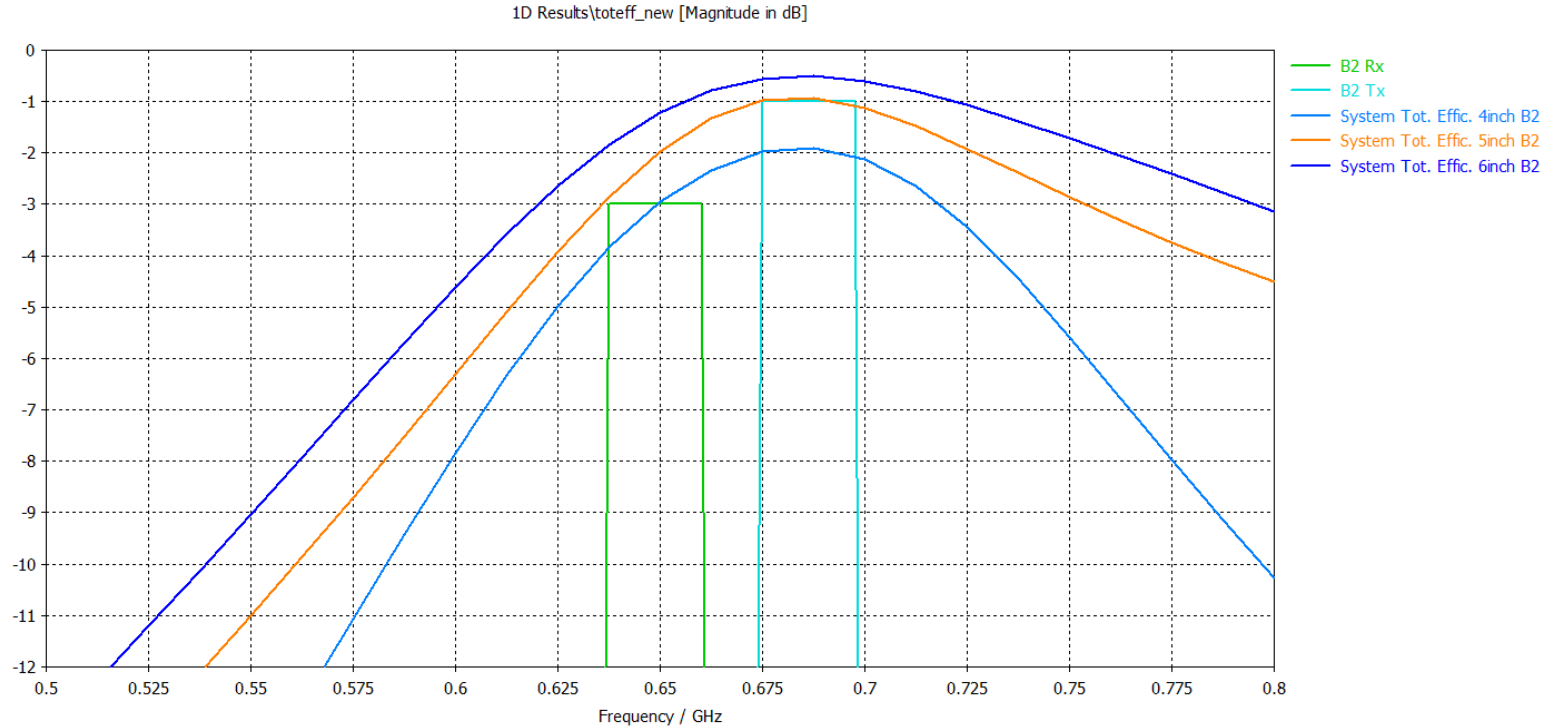
Total efficiencies for band combination A2



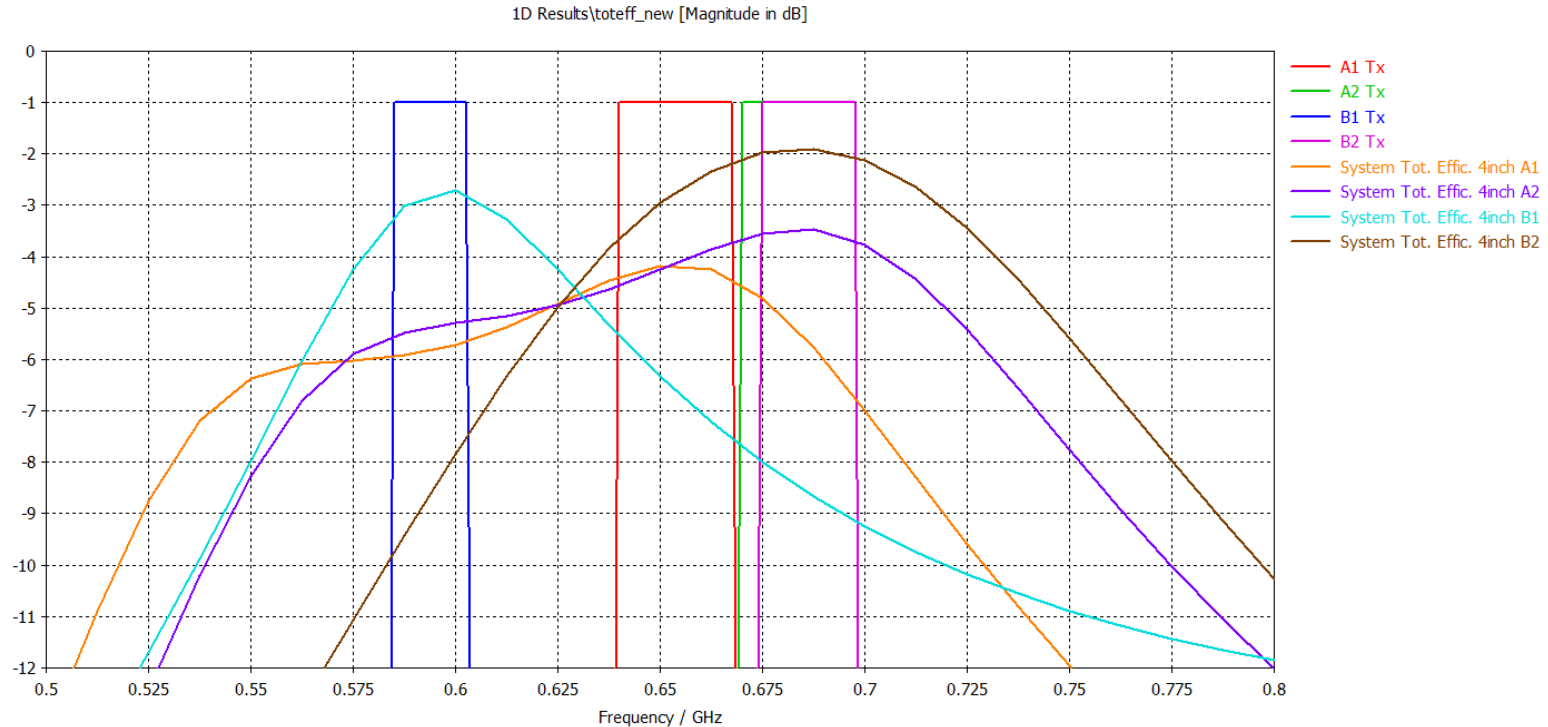
Matching levels for band combination B2



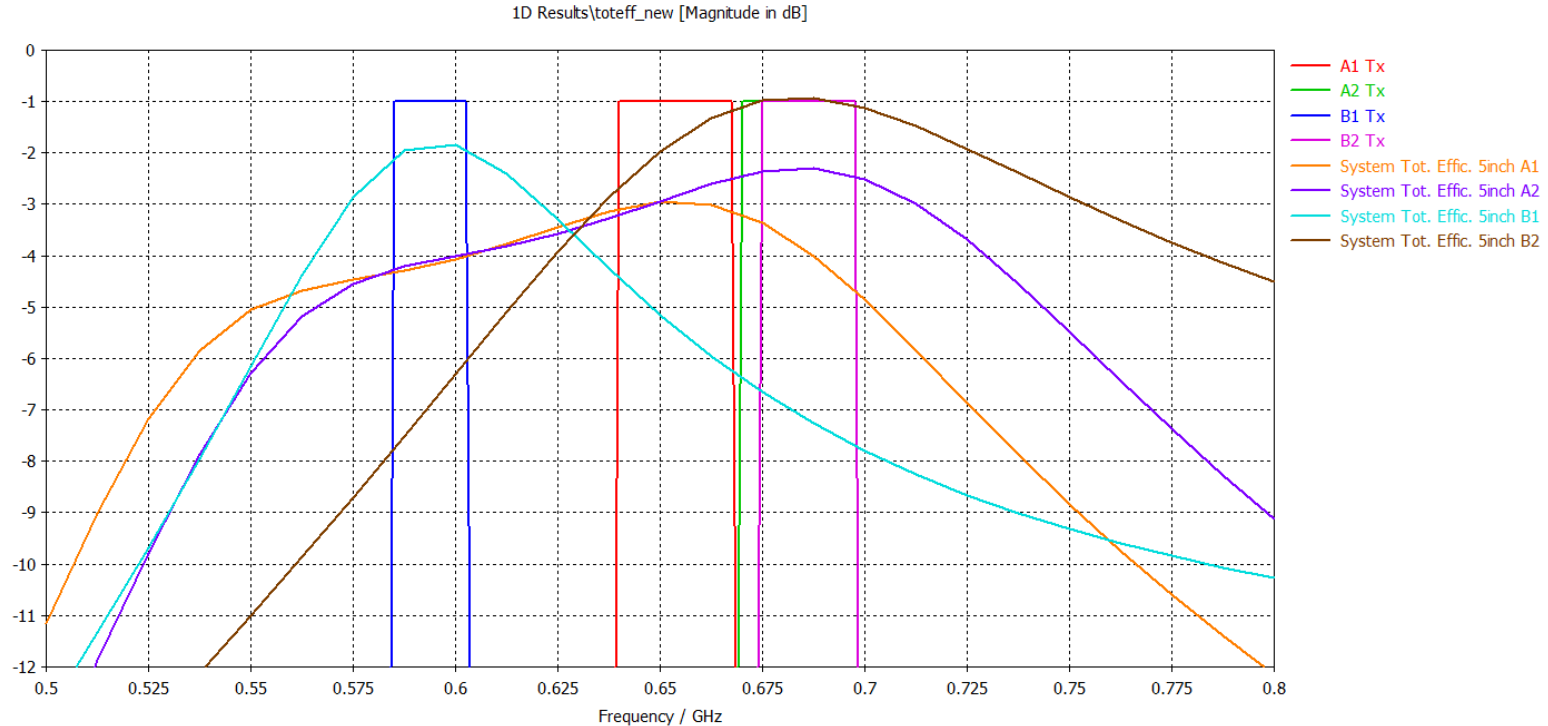
Total efficiencies for band combination B2



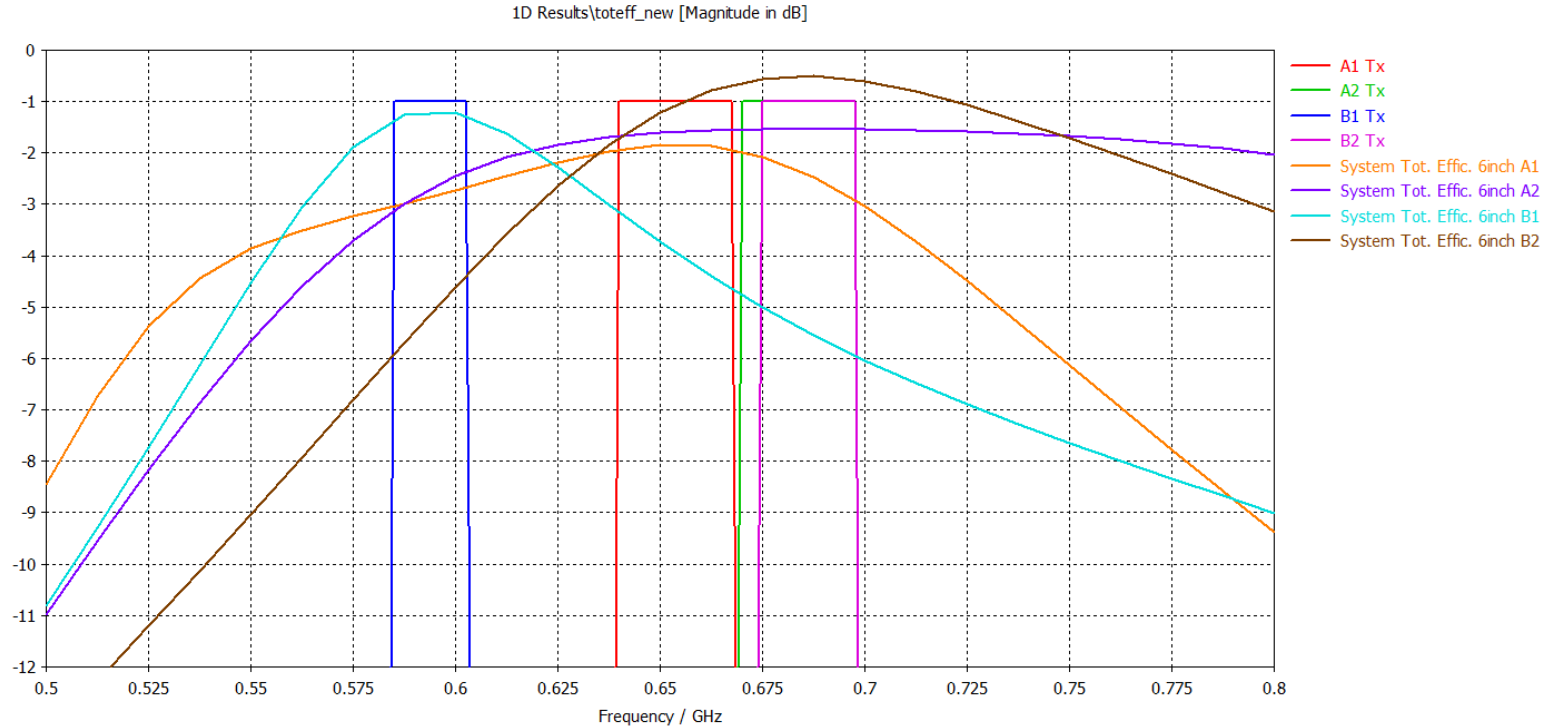
Total efficiencies for 4-inch devices



Total efficiencies for 5-inch devices

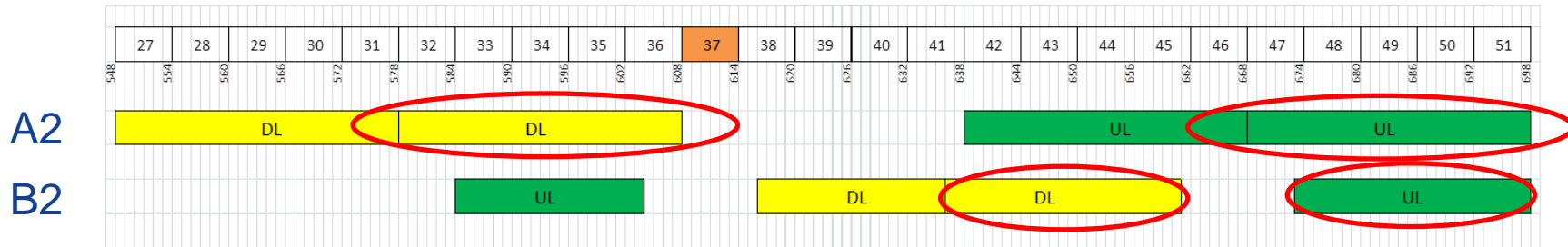


Total efficiencies for 6-inch devices



Summary for band combinations 'A2' and 'B2' using an antenna designed for the 600 MHz band

- 1.0 to 1.5 dB better efficiency with 'B2' when compared to 'A2' at Tx frequencies
- Matching not good enough with 'A2' at Rx frequencies



B17 antenna tuned to 600 MHz: 'A2' and 'B2'

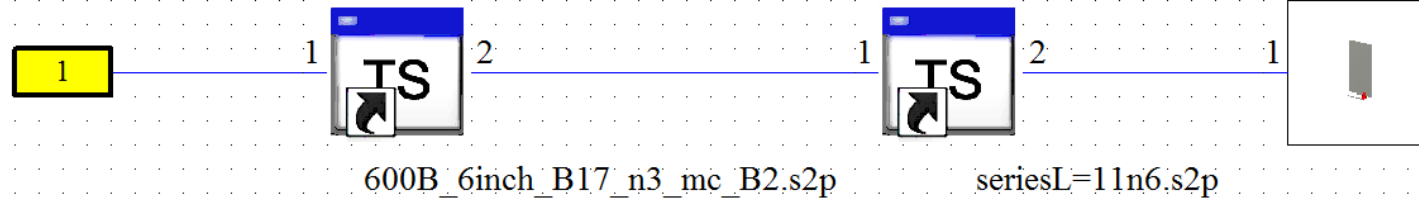
Optimize for 2 dB worse efficiency for Rx
frequencies in Optenni Lab

Total efficiency calculations for B17 antenna optimized at 600 MHz

Lossy matching network
optimized for the 600 MHz
band

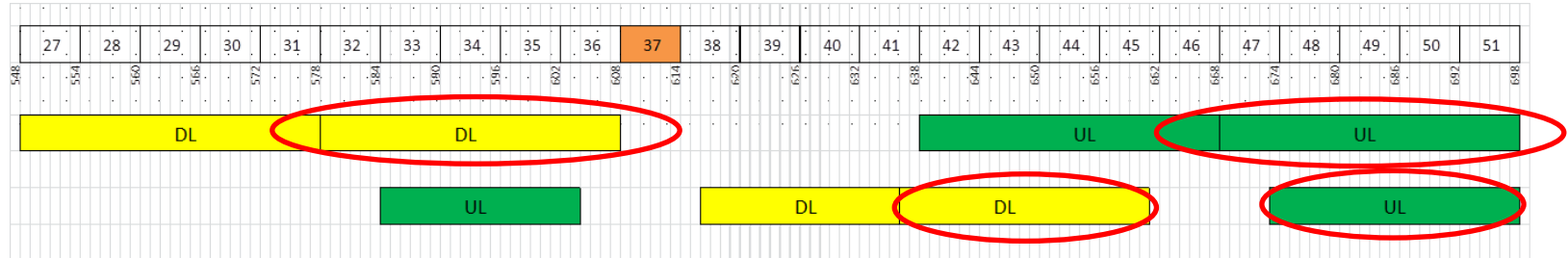
Lossy inductor from
the B17 matching
circuit

Lossless and
simple antenna
model

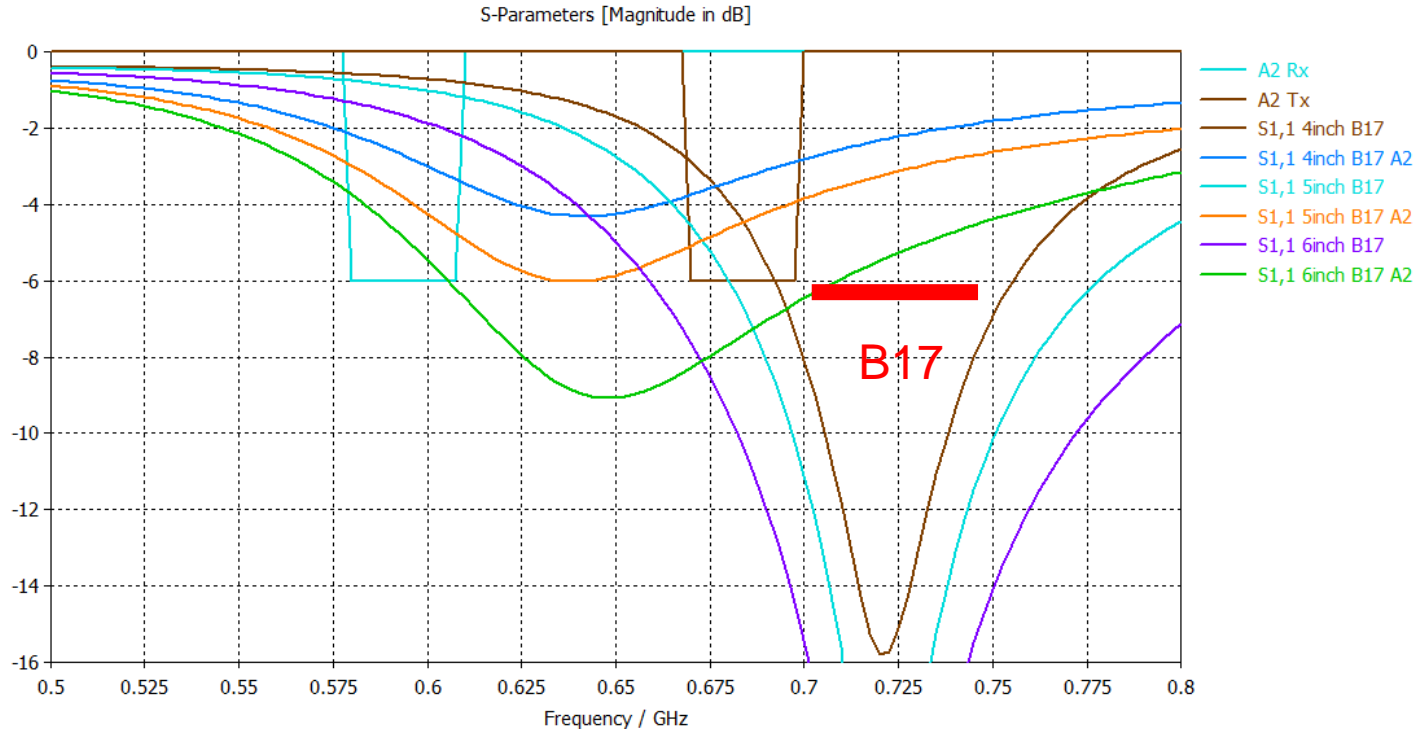


A2

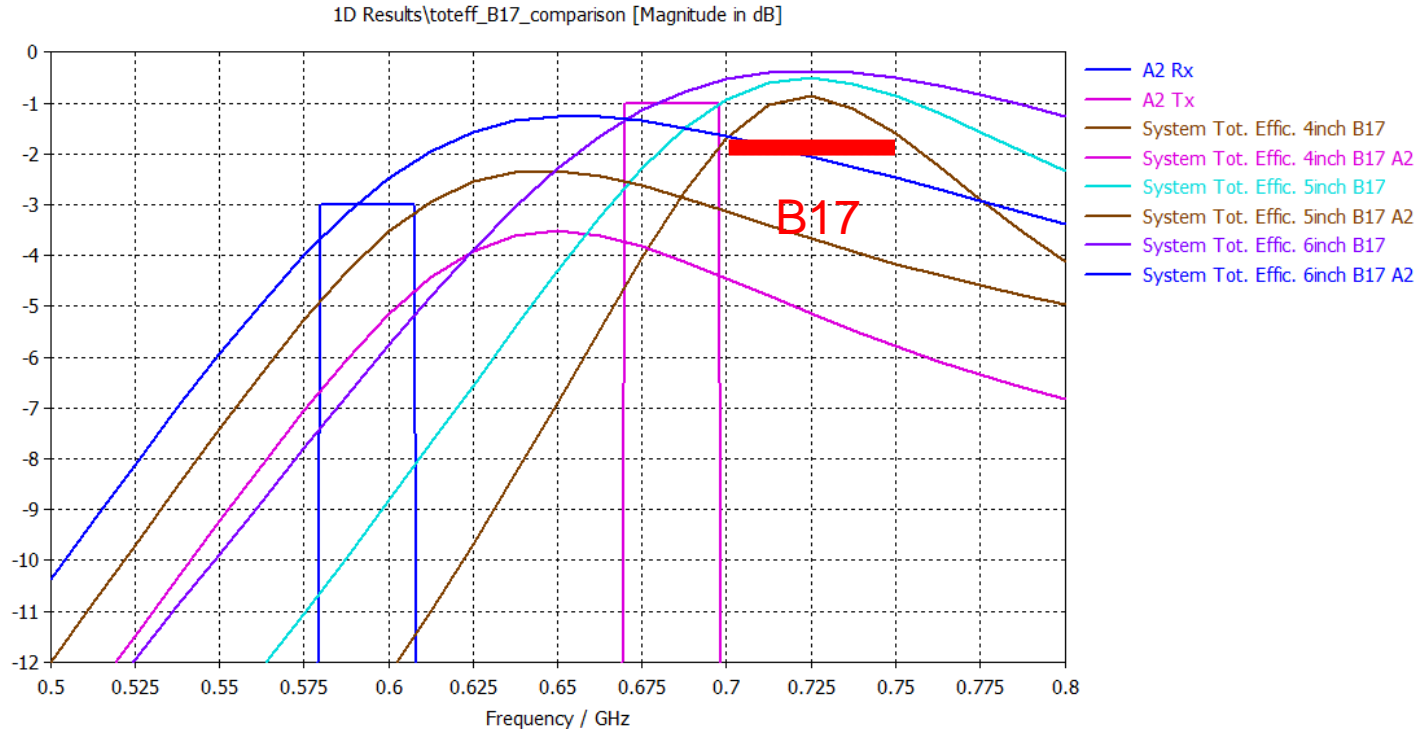
B2



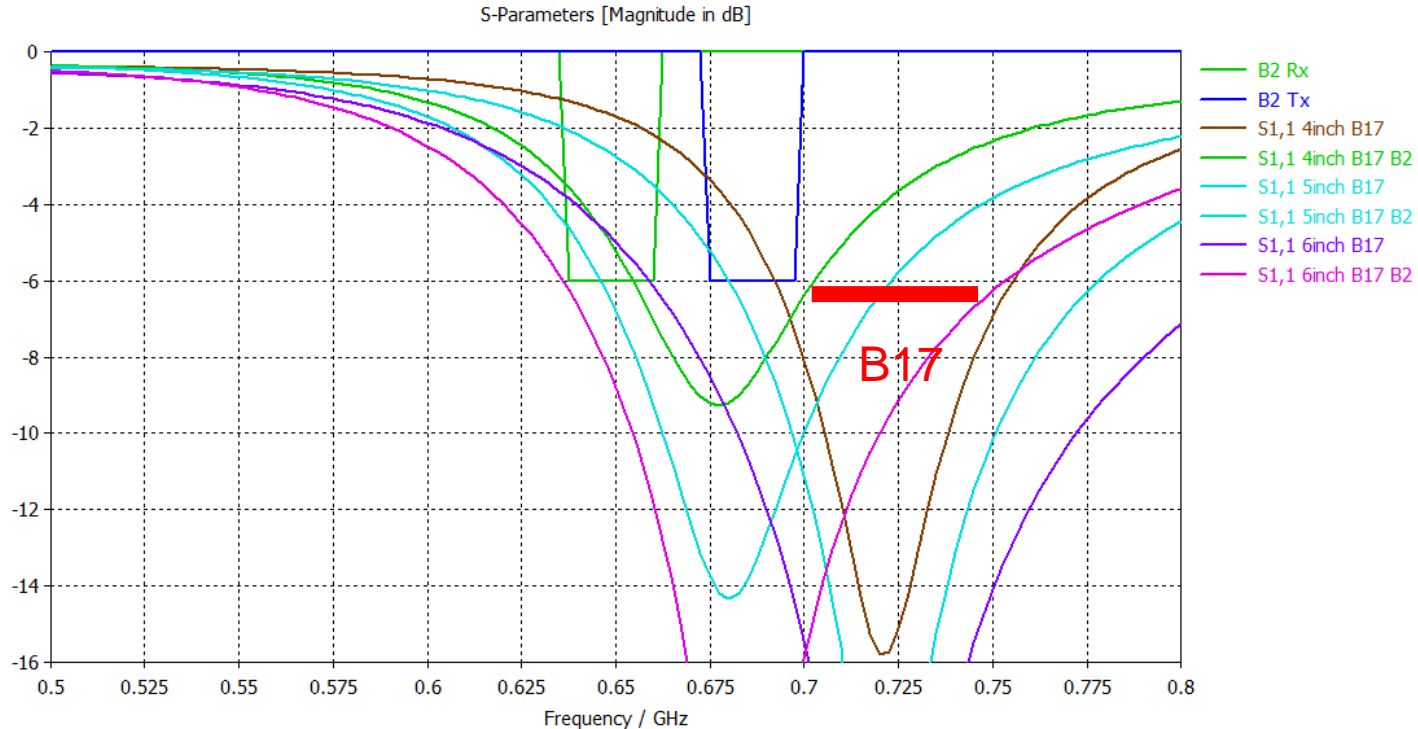
Matching levels for band combination A2 (B17 antenna)



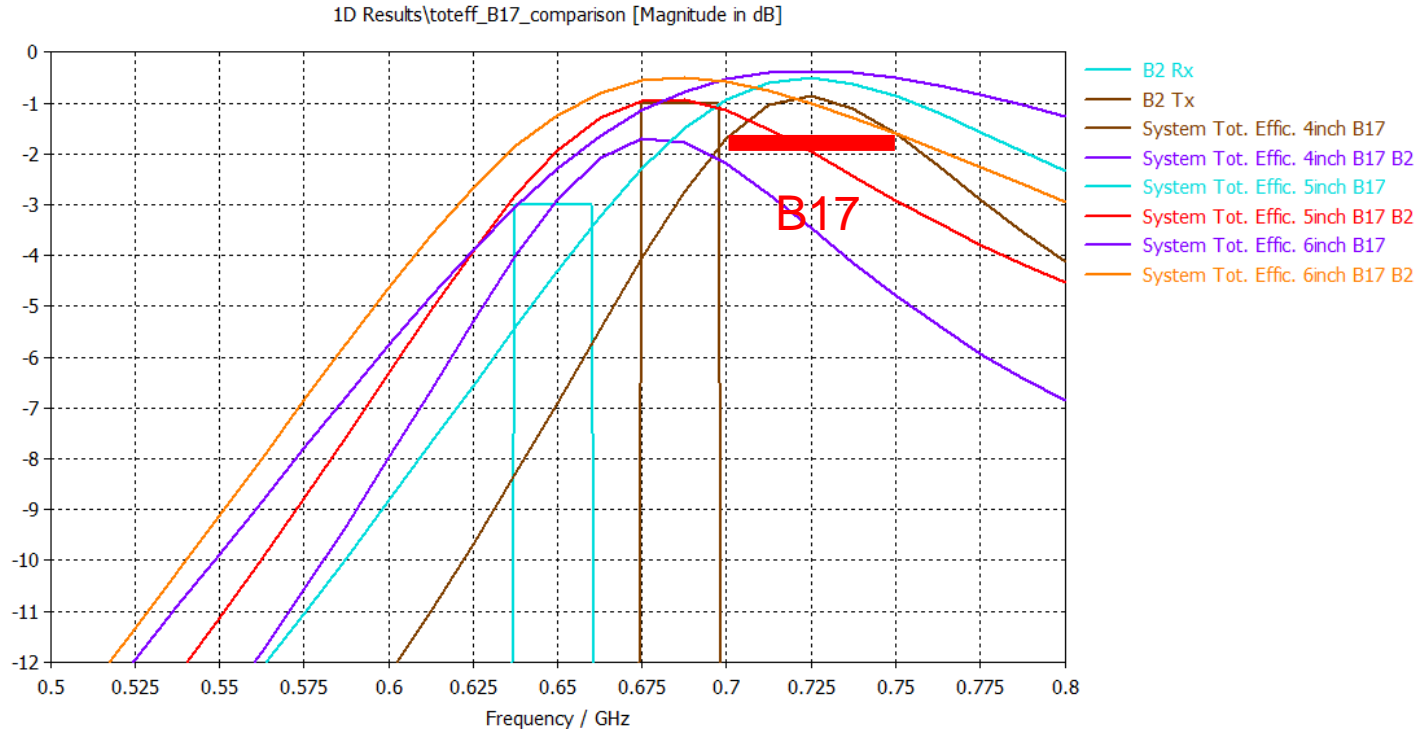
Total efficiencies for band combination A2 (B17 antenna)



Matching levels for band combination B2 (B17 antenna)

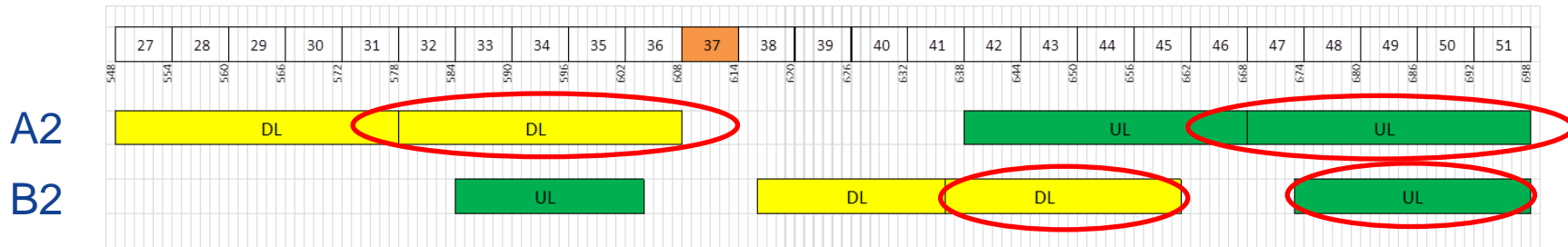


Total efficiencies for band combination B2 (B17 antenna)



Summary for band combinations 'A2' and 'B2' using a B17 antenna

- B17 antenna can be tuned down in frequency in the 'A2' case only with 6 inch devices. In that case the efficiency penalty is about 1 dB and the matching at Rx frequencies is not good enough.
- In 'B2' case smaller devices can be tuned down with less than 1 dB efficiency penalty. 5 and 6 inch devices have good matching at Rx frequencies as well.

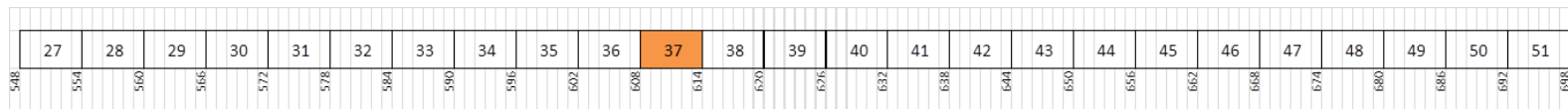


Emphasis on Tx frequencies and only
the 600-MHz band considered

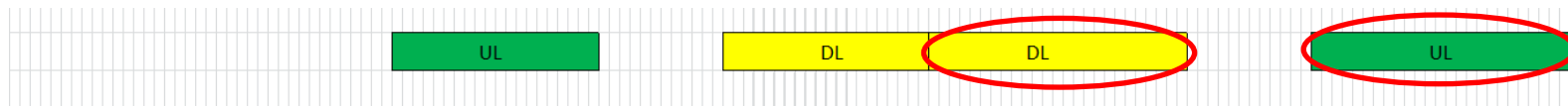
B2: 2x25MHz UL/DL

B3: 2x35MHz UL/DL

600 MHz band plan proposals 'B2' and 'B3'



'B2'

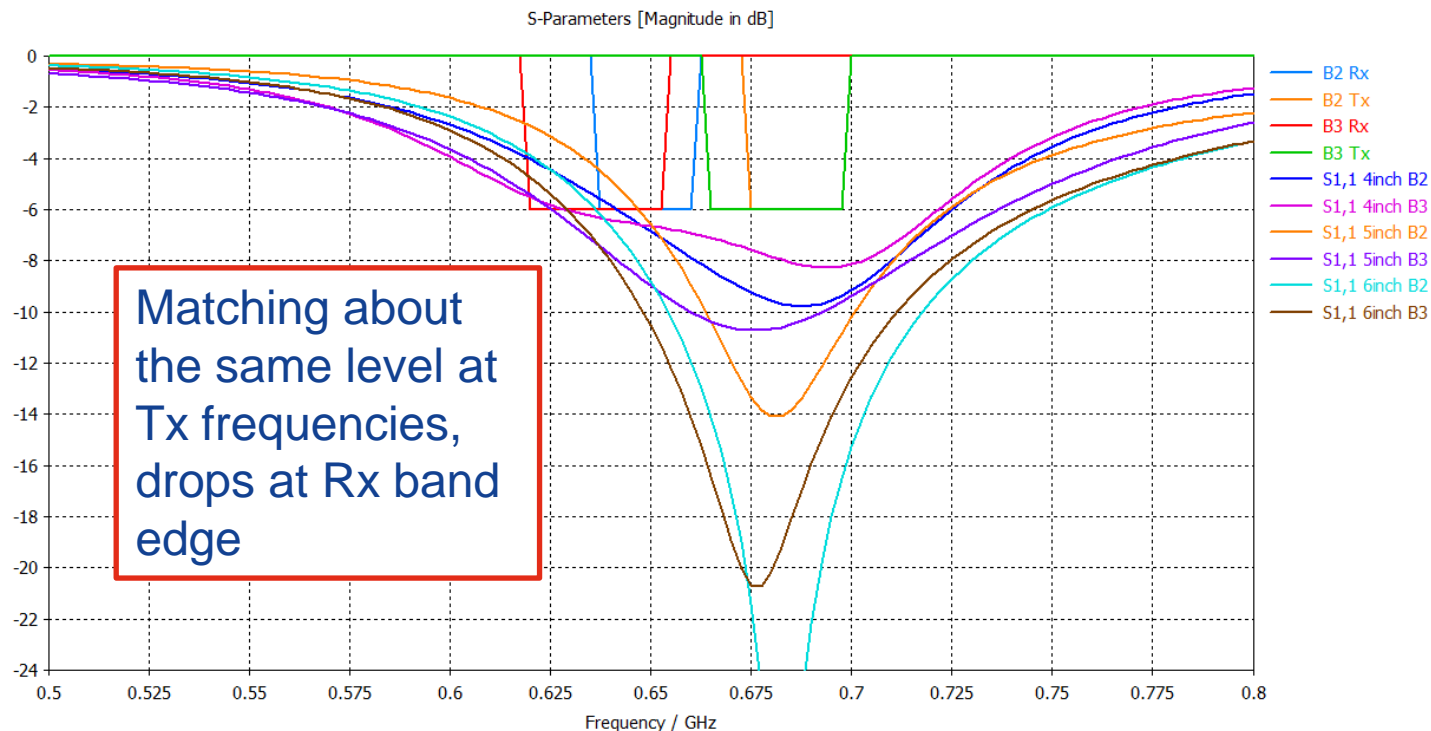


'B3'

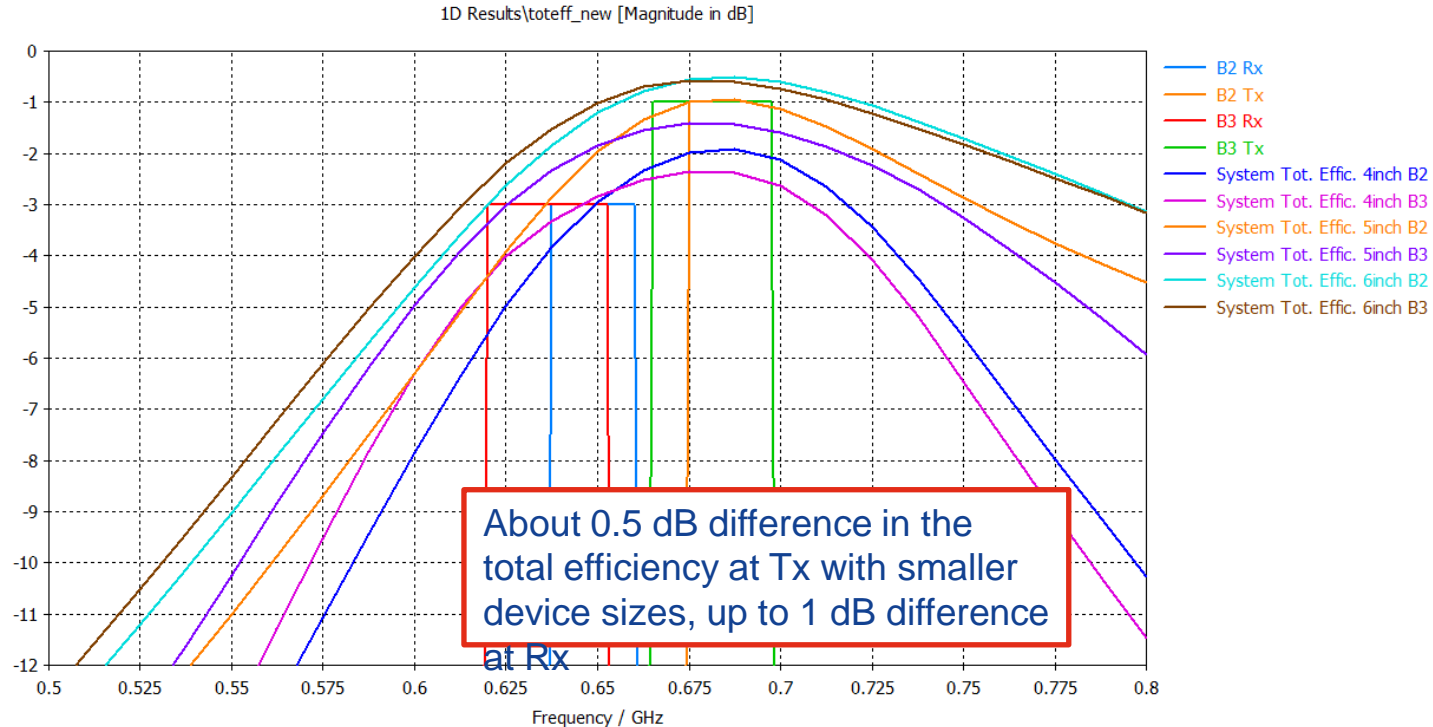


Band	UL [MHz]	DL [MHz]	BW [MHz]	BW [%]
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B1	584-604	616-636	20	8.5
B2	673-698	636-661	25	9.3
B3	663-698	618-653	35	12.2
B4	673-698	588-608, 618-663	25/75	17.1

Matching levels for band combinations 'B2' and 'B3'

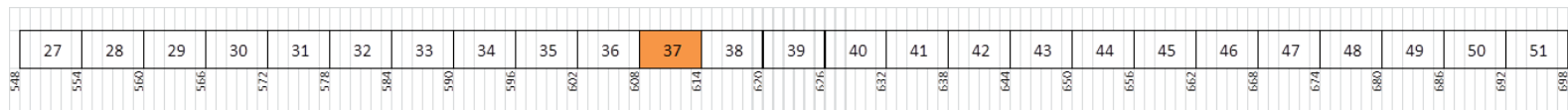


Total efficiencies for band combinations 'B2' and 'B3'

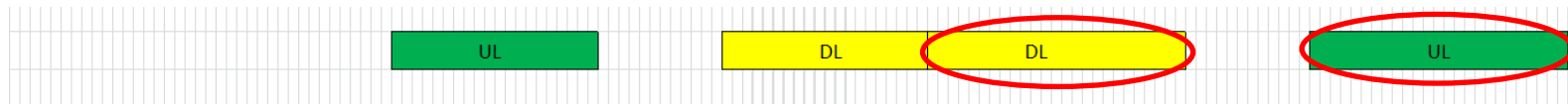


Summary for band combinations 'B2' and 'B3'

- With similar antenna and device size, 'B3' has about 0.5 dB worse efficiency at Tx frequencies
- At the lower Rx band edge, 'B3' has about 1 dB worse efficiency



'B2'



'B3'

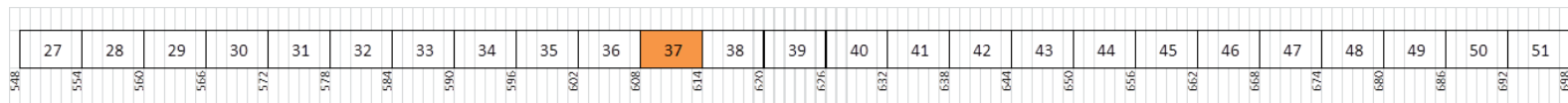


Emphasis on Tx frequencies and only
the 600-MHz band considered

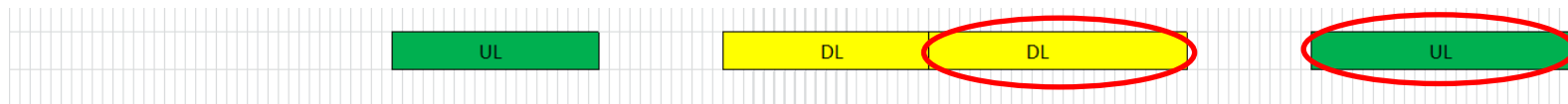
B2: 2x25MHz UL/DL

B4: 2x25MHz UL/DL + 2x20MHz DL/DL

600 MHz band plan proposals 'B2' and 'B4'



'B2'

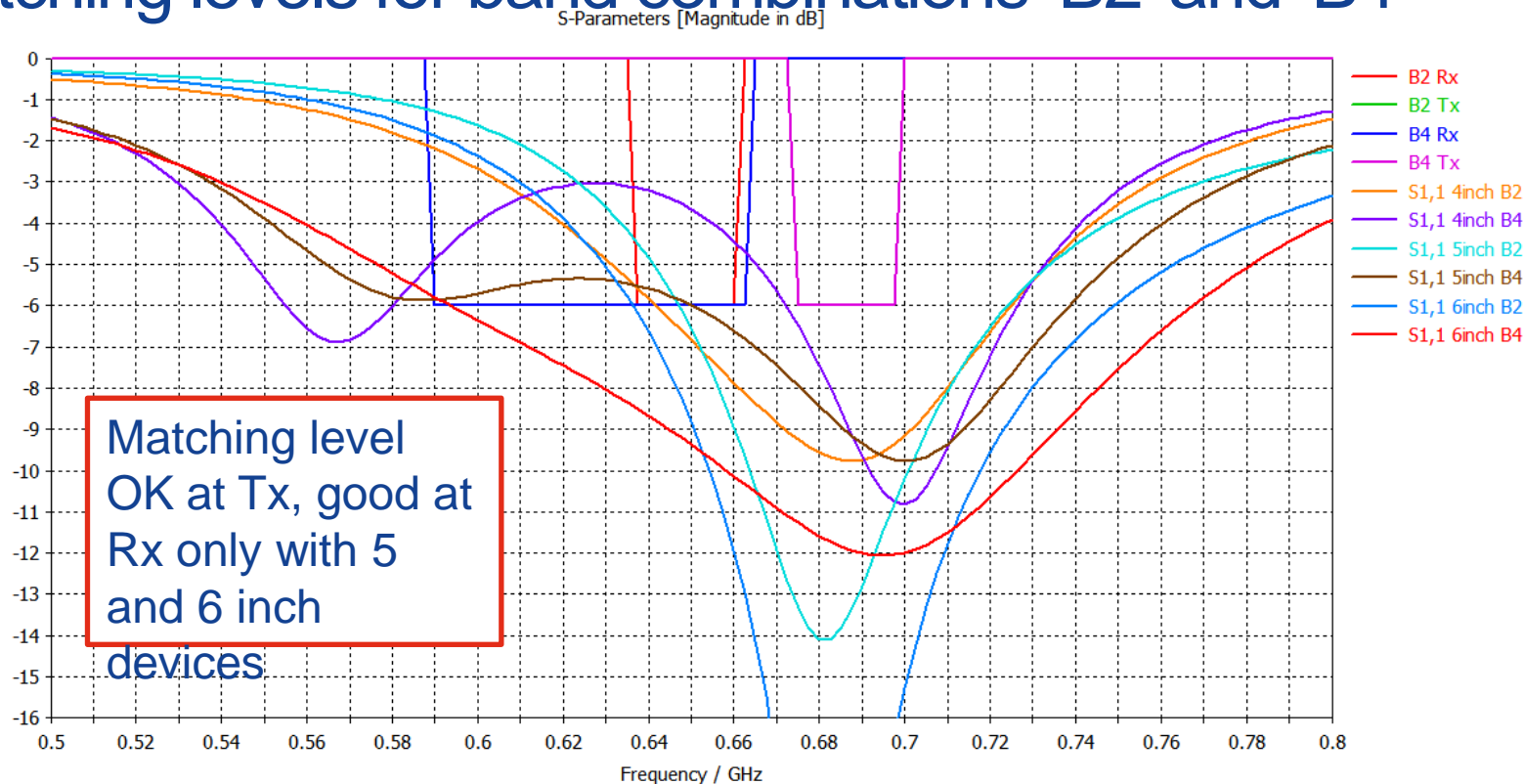


'B4'

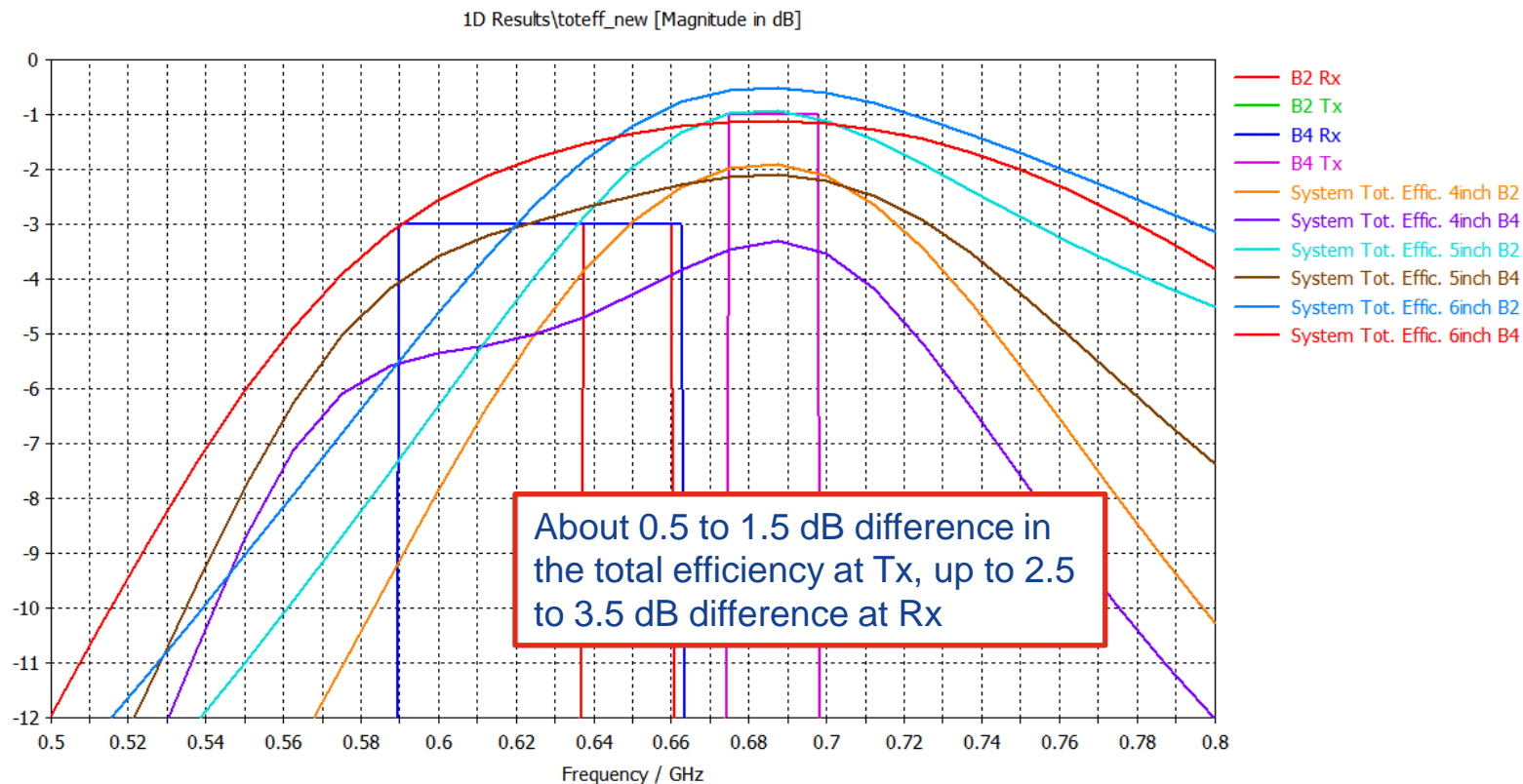


Band	UL [MHz]	DL [MHz]	BW [MHz]	BW [%]
A1	638-668	548-578	30	19.7
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B1	584-604	616-636	20	8.5
B2	673-698	636-661	25	9.3
B3	663-698	618-653	35	12.2
B4	673-698	588-608, 618-663	25/75	17.1

Matching levels for band combinations 'B2' and 'B4'

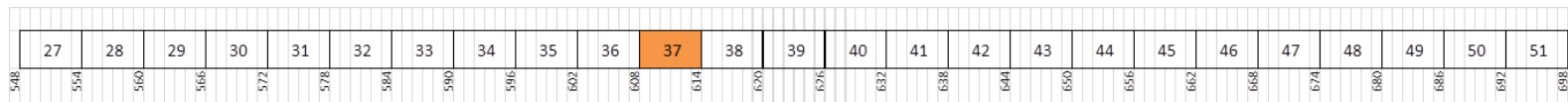


Total efficiencies for band combinations 'B2' and 'B4'

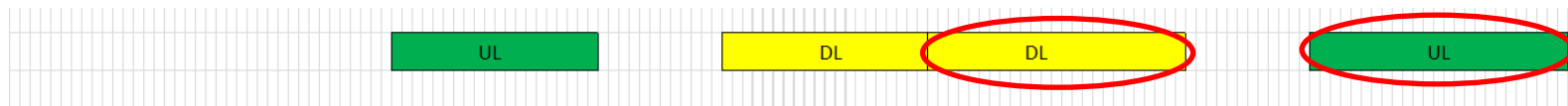


Summary for band combinations 'B2' and 'B4'

- With similar antenna and device size, 'B2' has about 0.5 to 1.0 dB worse efficiency at Tx frequencies
- At the lower Rx band edge, 'B2' has about 2.5 to 3.5 dB worse efficiency



'B2'

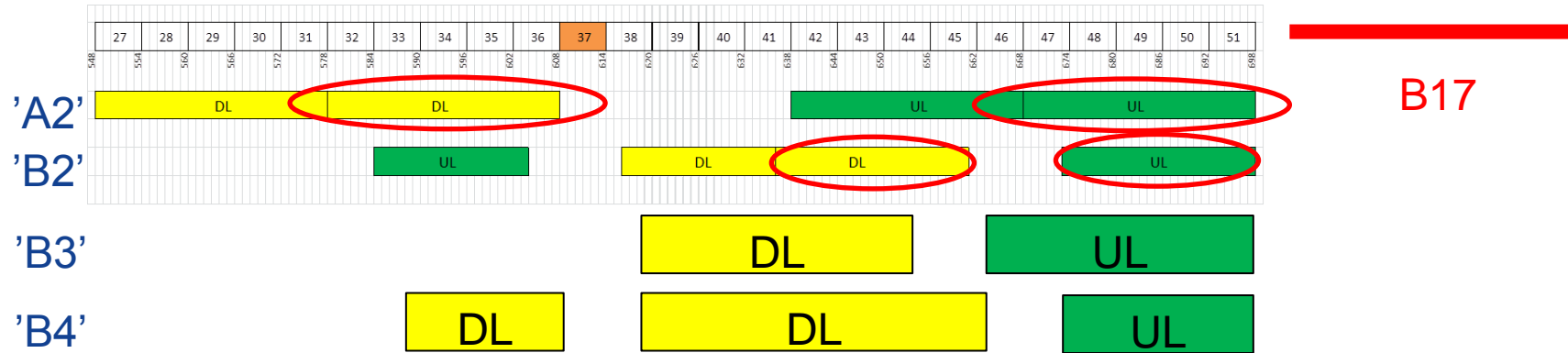


'B4'



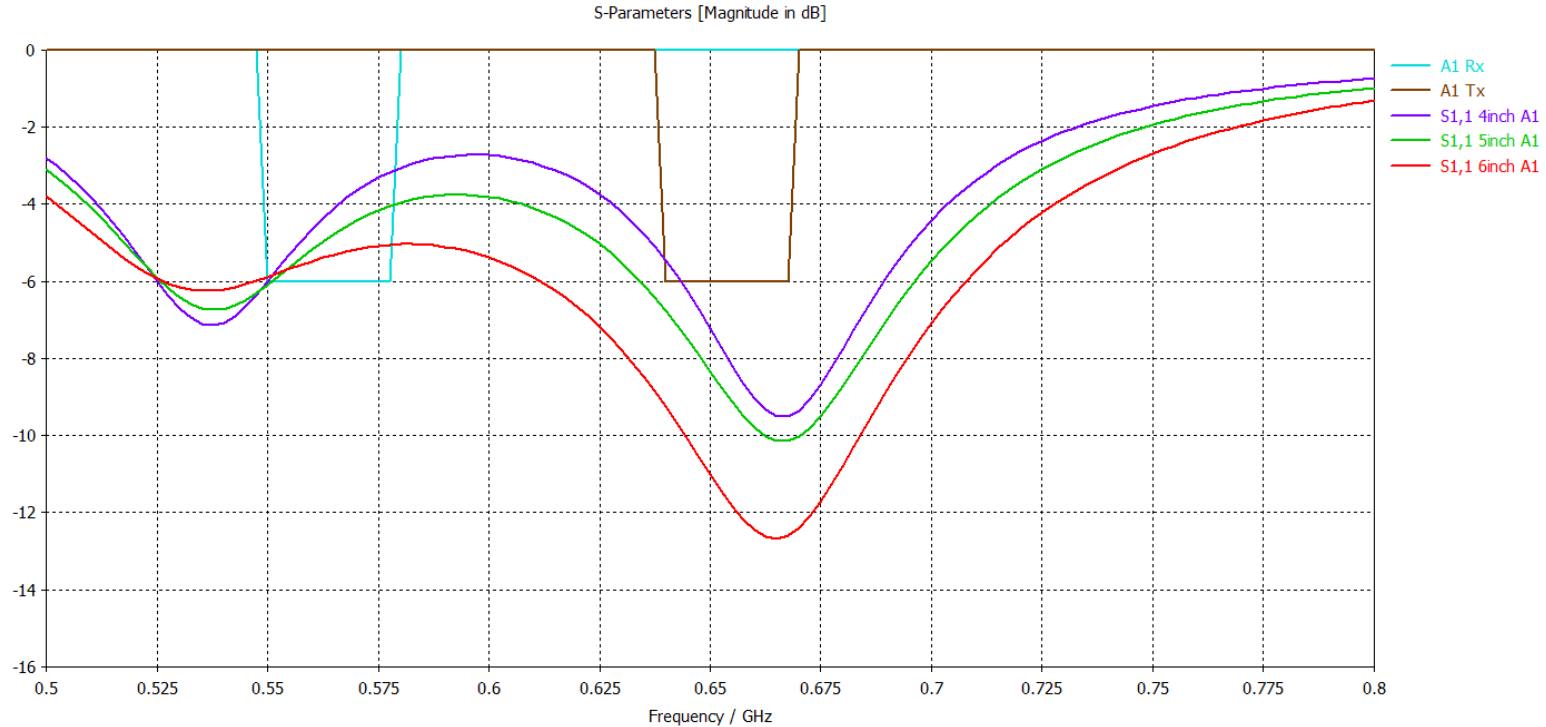
Conclusion

1. The closer the Tx and Rx bands are the better, the efficiency and matching are
2. The higher the absolute band is in frequency, the better the performance
3. If a B17 antenna should be used at 600 MHz, the 600-MHz band should be right next to it
4. As a separate antenna, 'B2' is the easiest case, 'B3' is most likely the second easiest, and 'A2' and 'B4' are the hardest

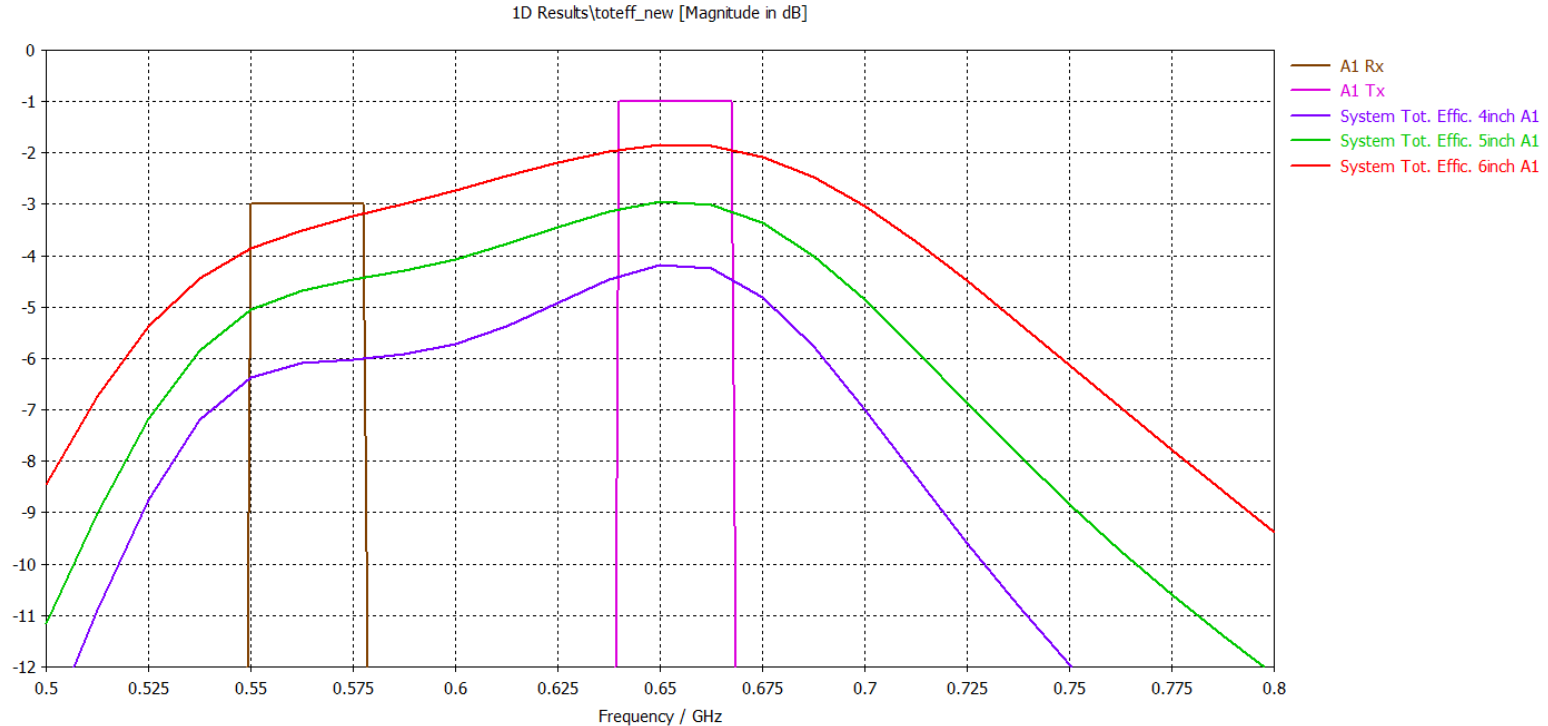


Back-up slides

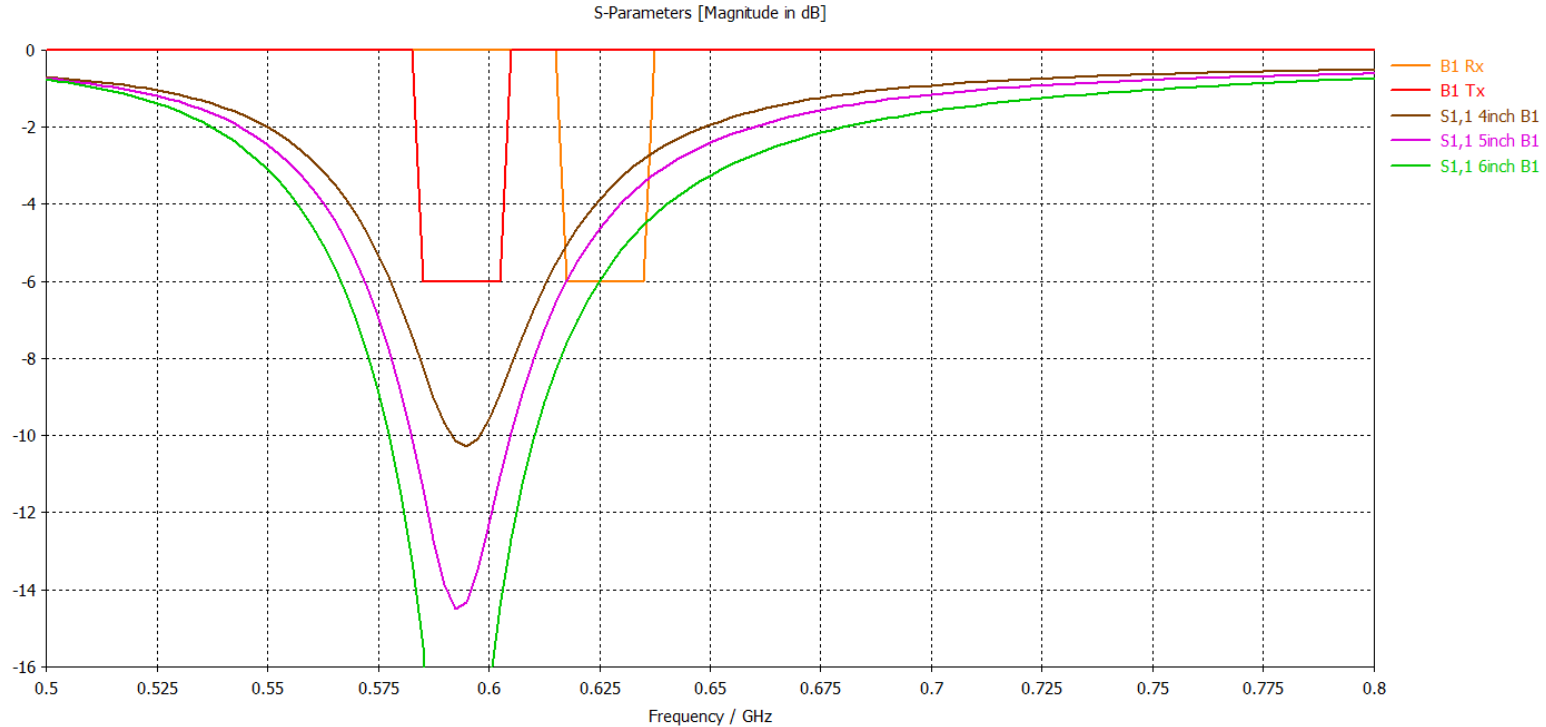
Matching levels for band combination A1



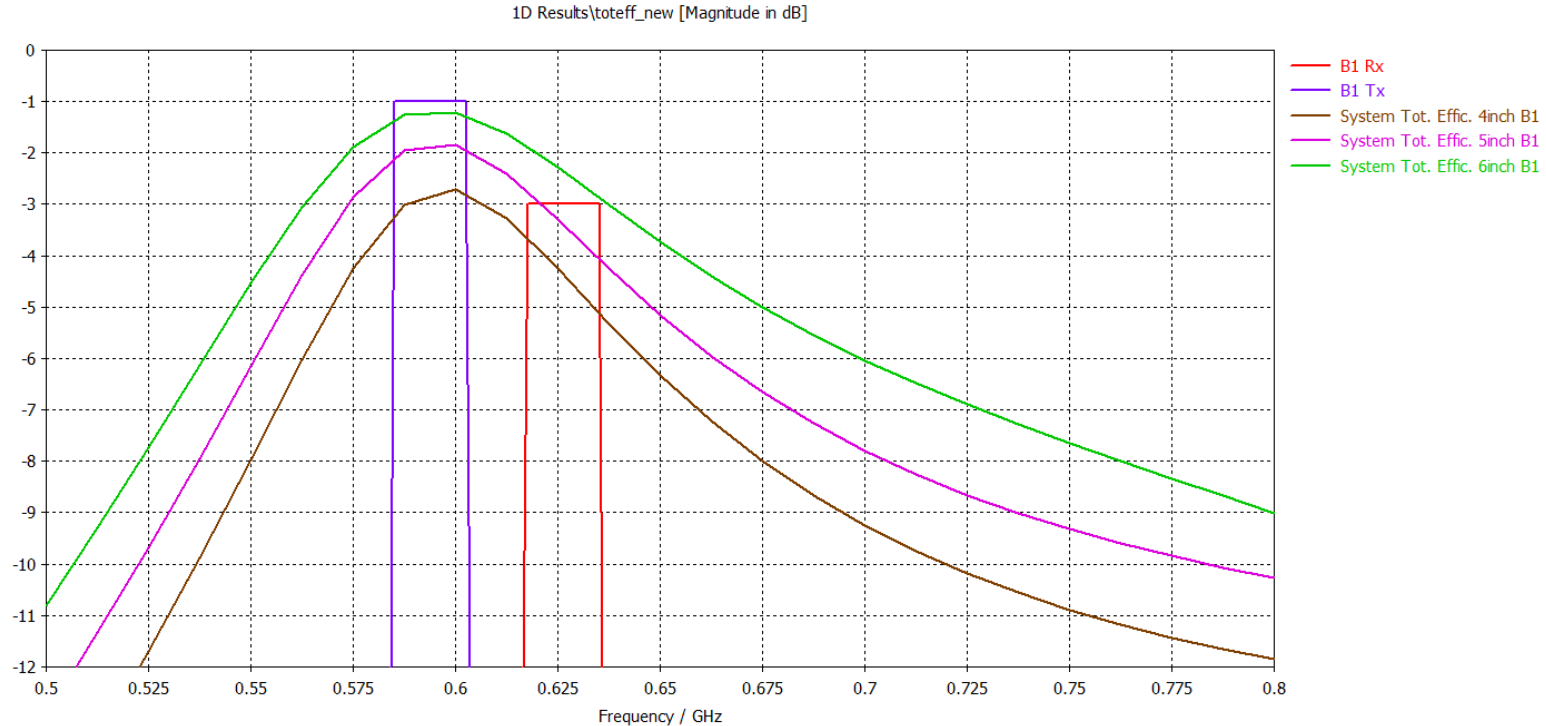
Total efficiencies for band combination A1



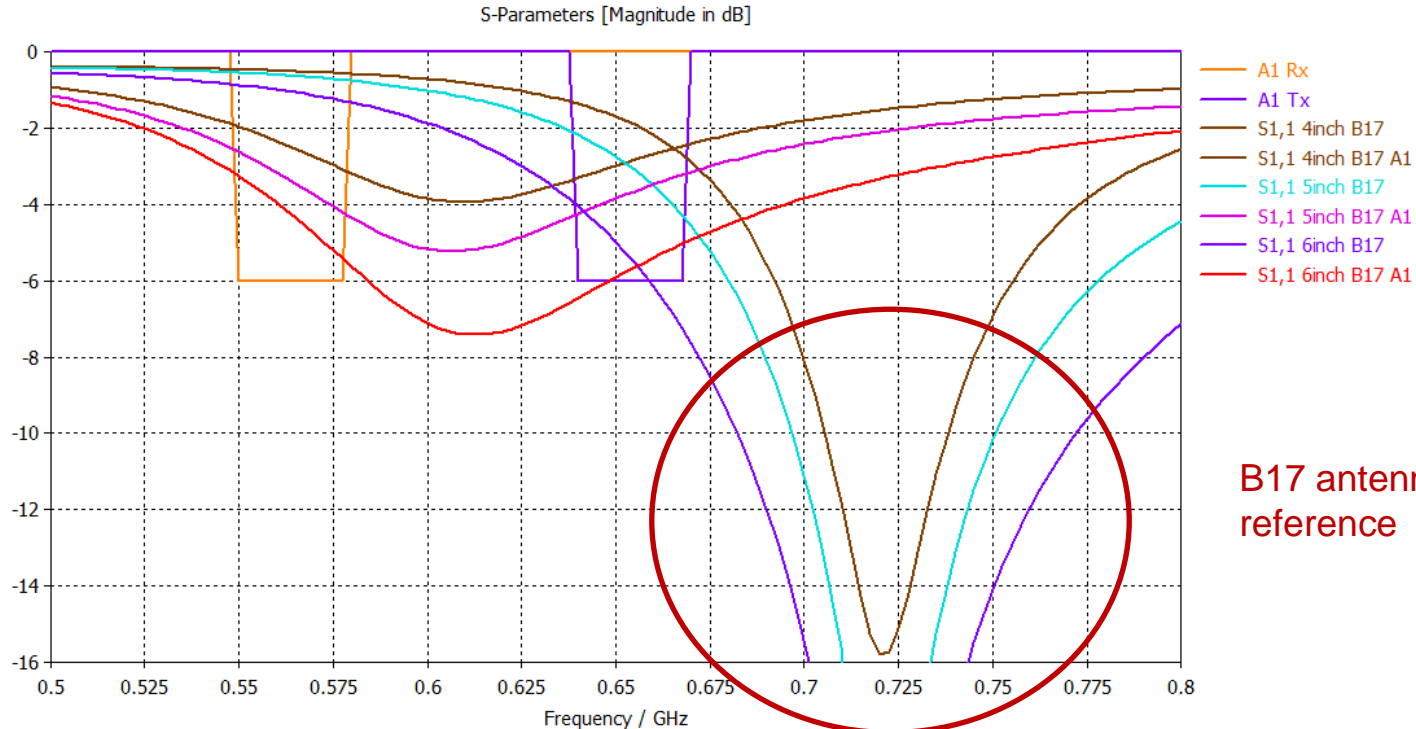
Matching levels for band combination B1



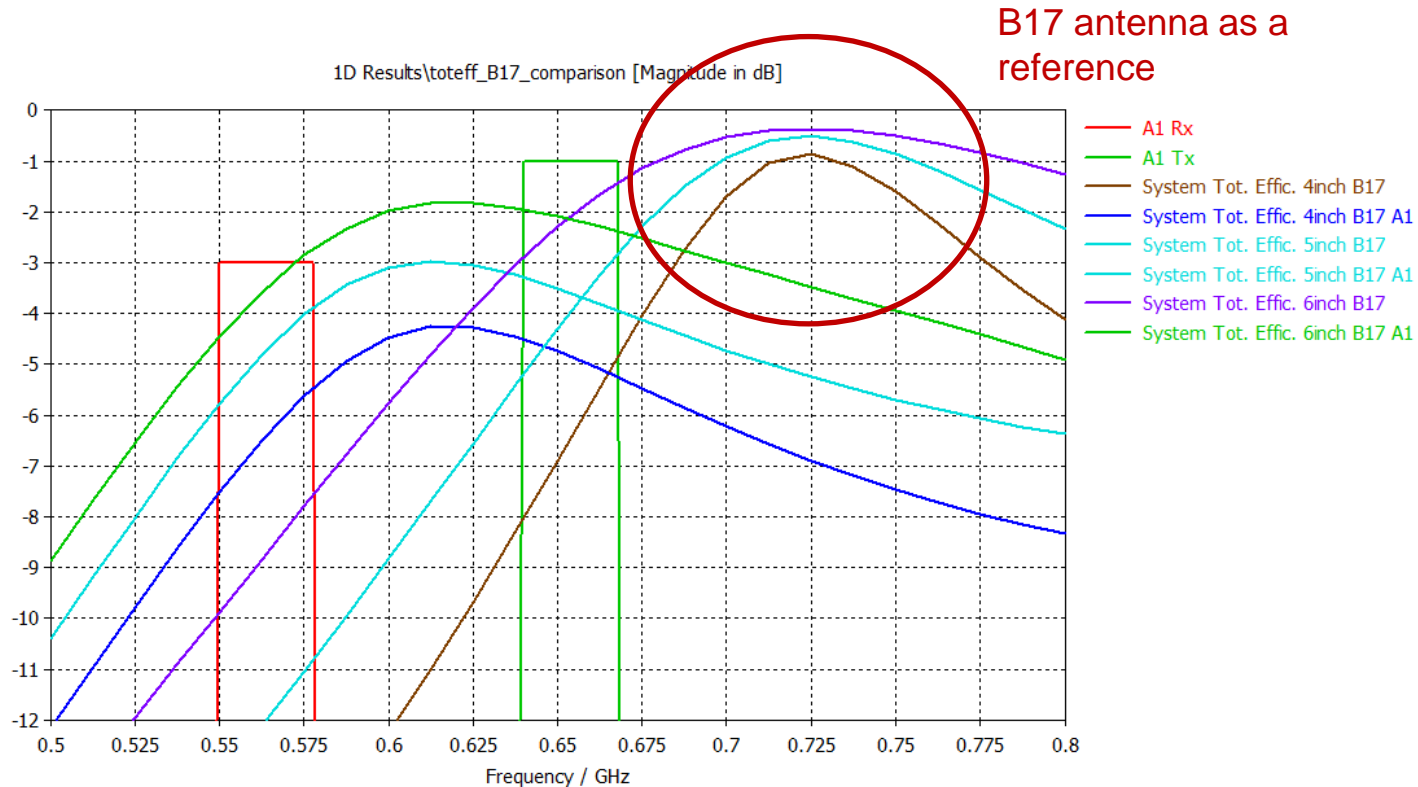
Total efficiencies for band combination B1



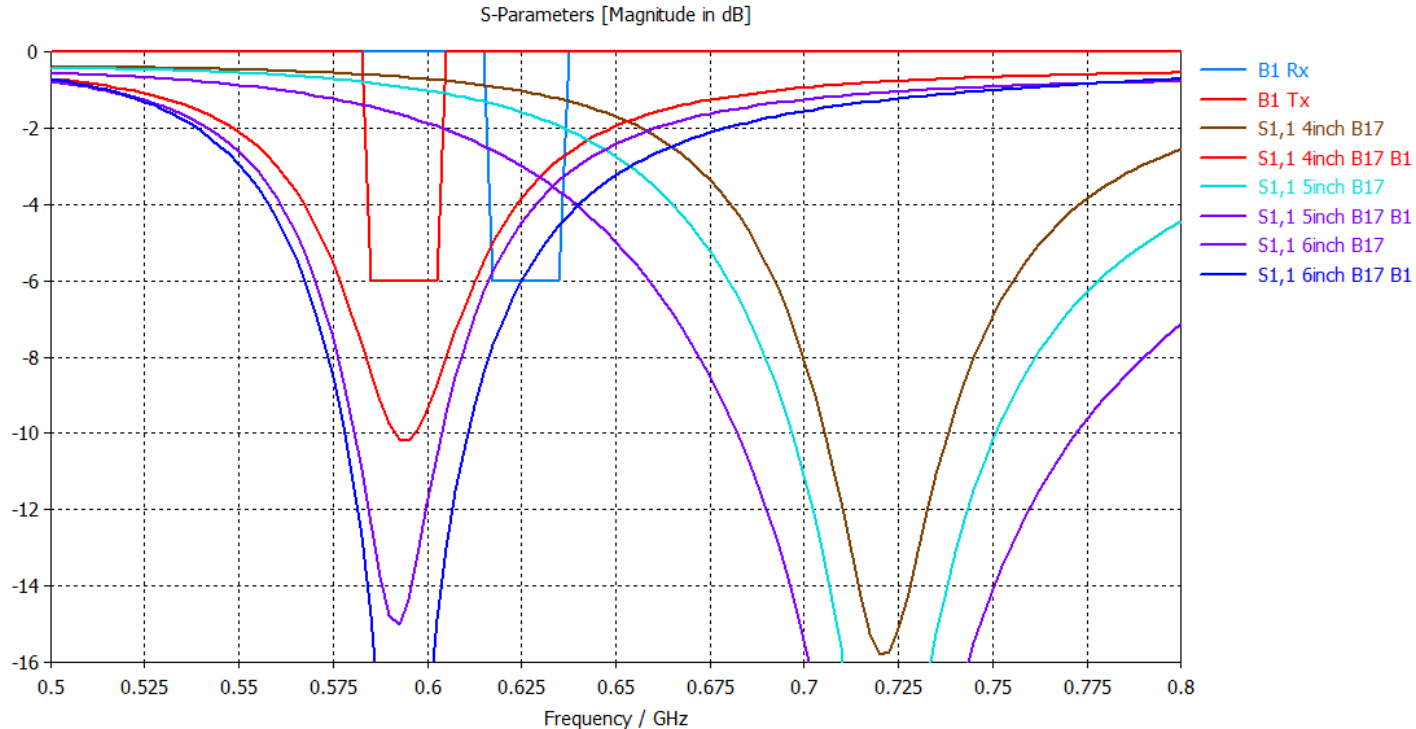
Matching levels for band combination A1 (B17 antenna)



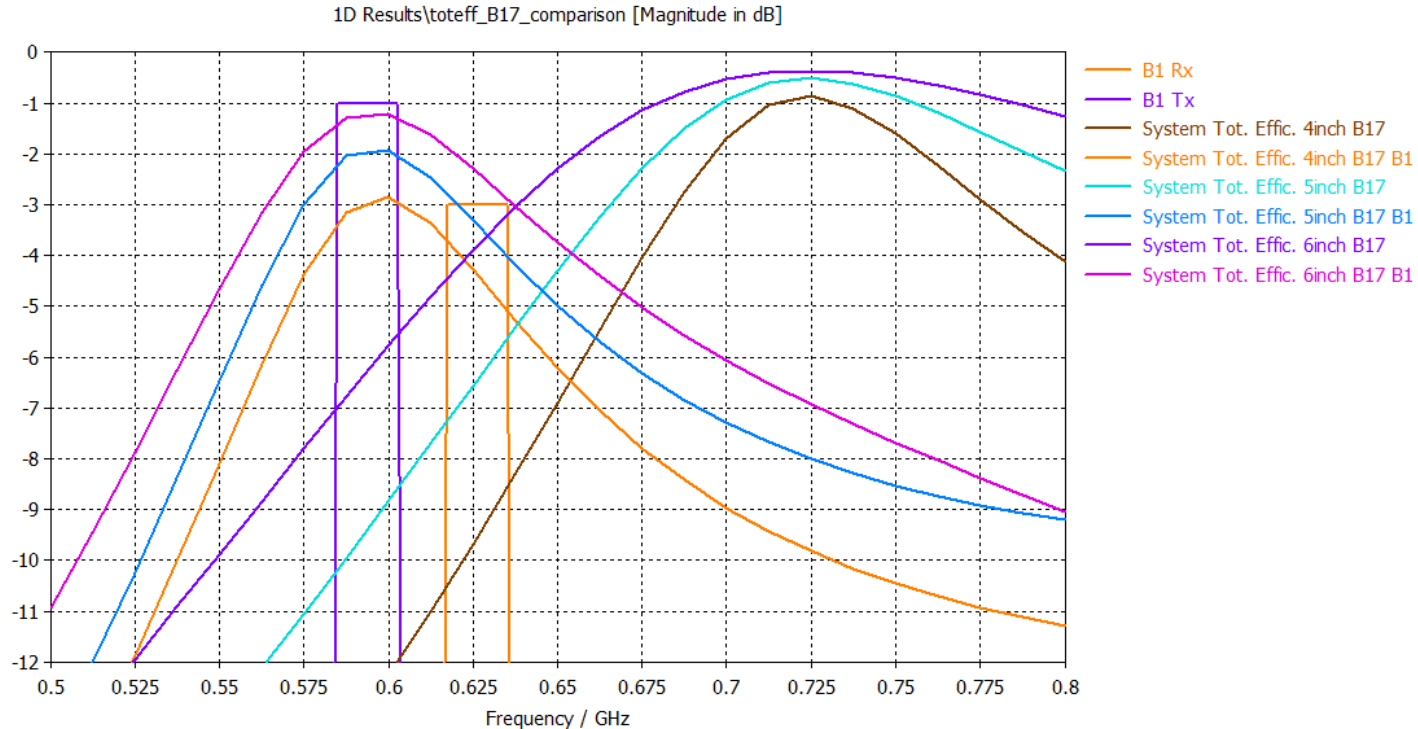
Total efficiencies for band combination A1 (B17 antenna)



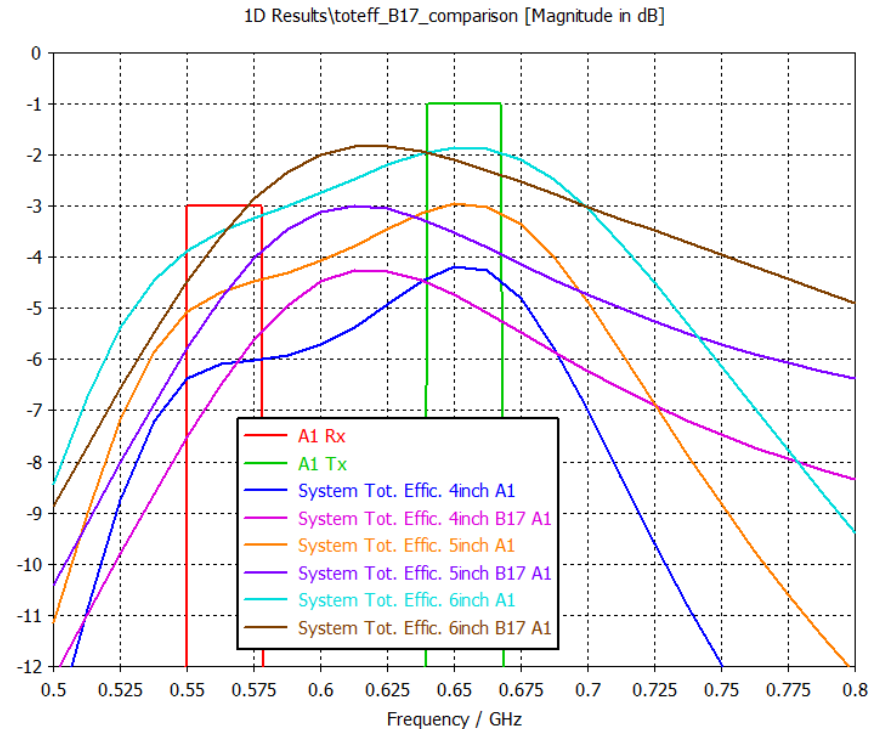
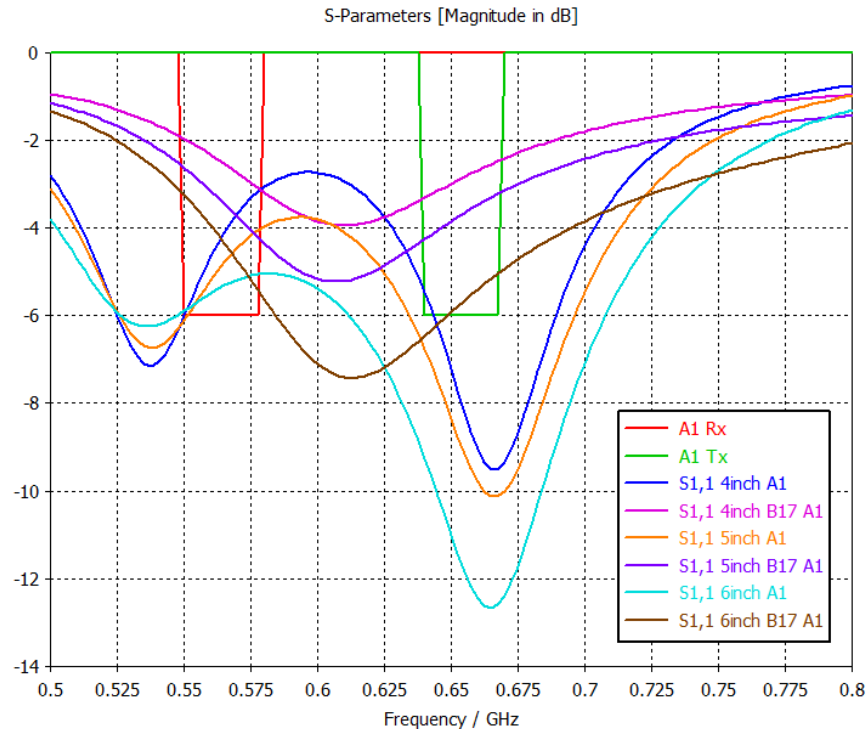
Matching levels for band combination B1 (B17 antenna)



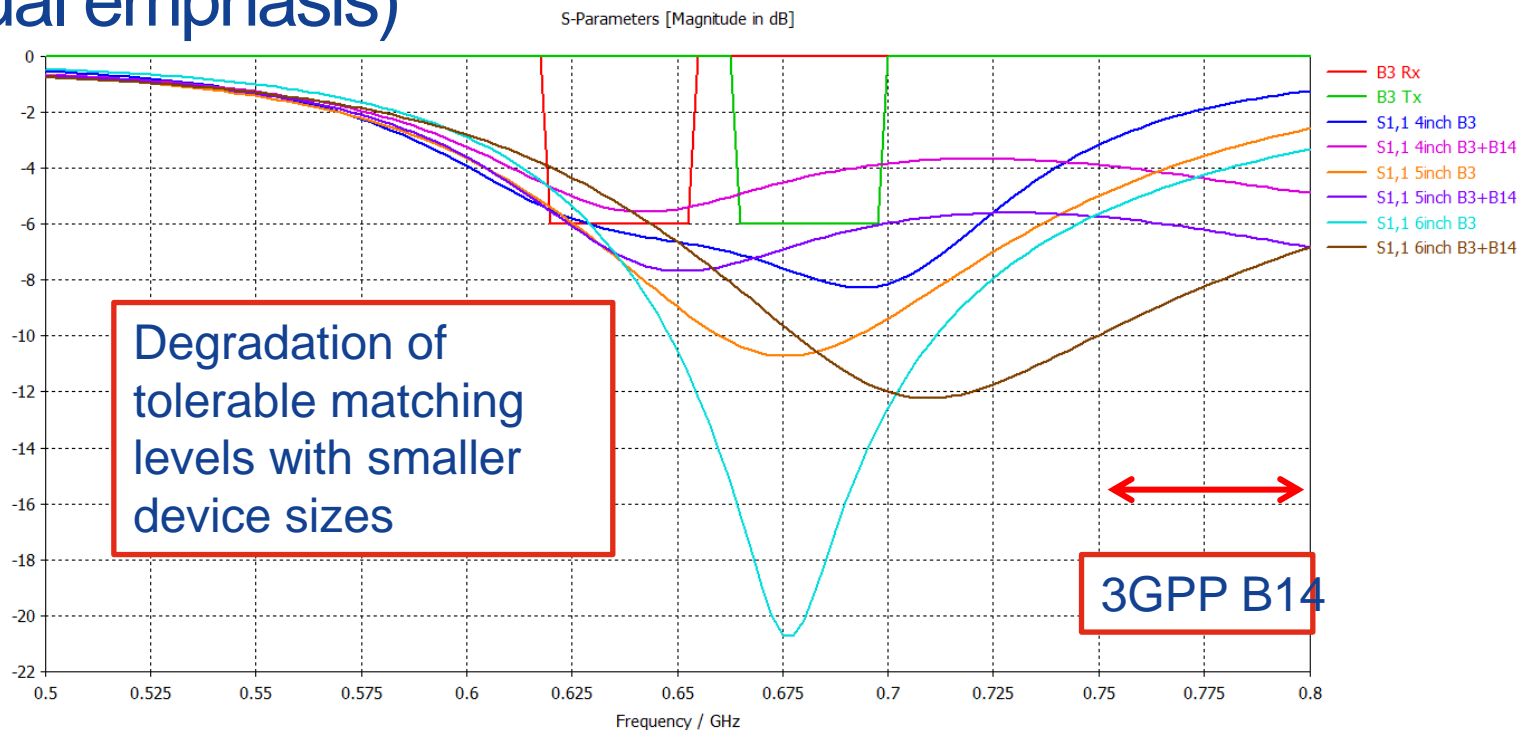
Total efficiencies for band combination B1 (B17 antenna)



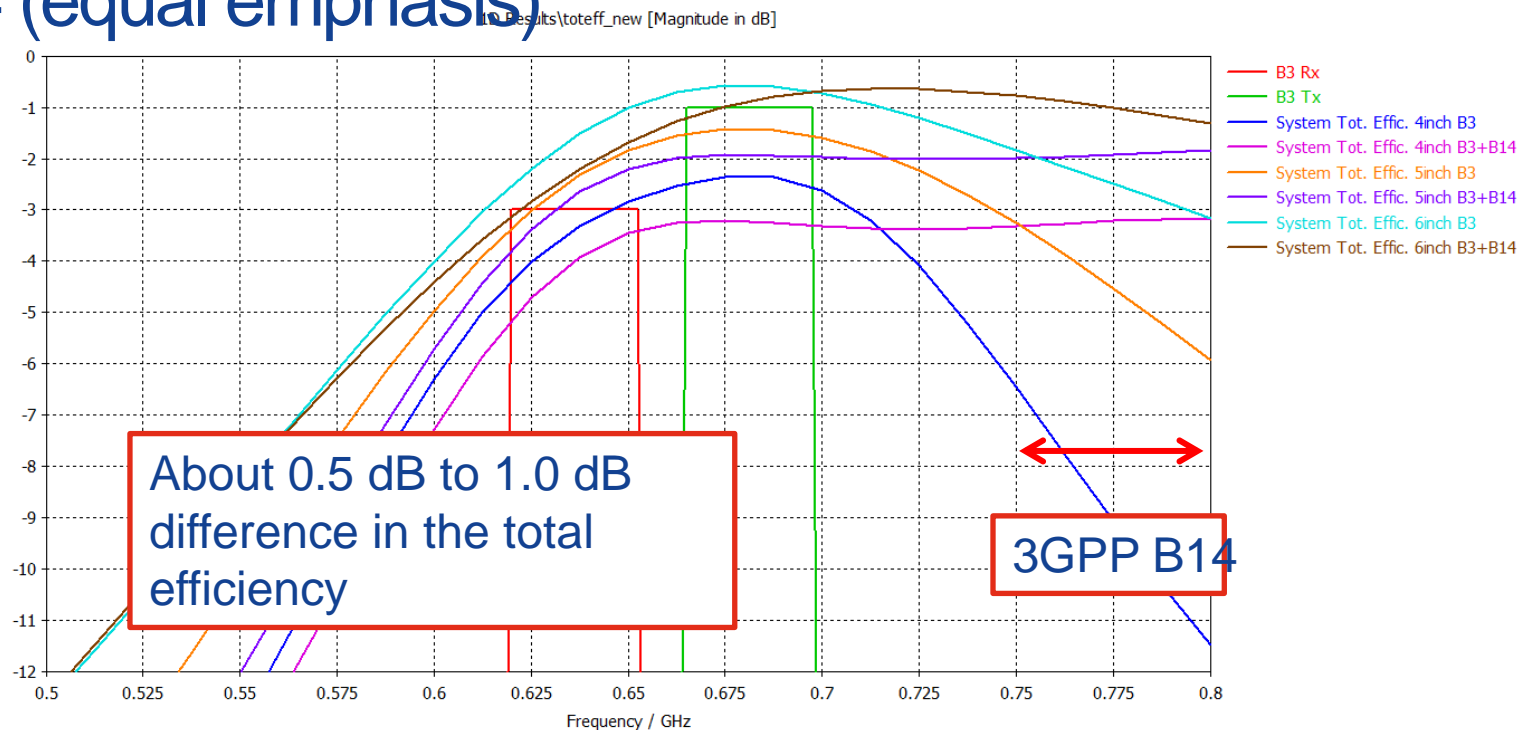
B17-to-600-MHz-optimized and 600-MHz-optimized antenna comparison: A1 (example)



Matching levels for band combinations 'B3' and 3GPP B14 (equal emphasis)



Total efficiencies for band combinations 'B3' and 3GPP B14 (equal emphasis)



Comments: 600 MHz only, A1, A2, B1, and B2

- Good matching levels (-6 dB) obtainable for all Tx frequencies, for Rx only with the 'B2' proposal.
- One inch increase in device size increases the total efficiency about 1 dB. The increase saturates with relatively large antennas with good matching levels
- 1 to 2 dB total-efficiency difference between the band proposals at Tx frequencies

Comments: 600 MHz with B17 antenna, A1, A2, B1, and B2

- Good matching levels (-6 dB) obtainable for all device sizes at Tx frequencies only in B1 and B2 cases and in the A2 case with 6-inch device
- One inch increase in device size increases the total efficiency about 1 dB. The increase saturates with relatively large antennas with good matching levels
- 1 to 2 dB total-efficiency difference between the band proposals at Tx frequencies
- 1 to 4 dB total-efficiency difference between B17 antenna and B17 antenna tuned at 600-MHz bands, also the matching difference can be large
- Not much difference in total efficiencies between B17-to-600-MHz and 600-MHz optimized antennas, large difference in matching

Conclusion (A1, A2, B1, and B2)

- As a general result, **one inch increase in device size increases the total efficiency about 1 dB**. This is due to the lower eigenfrequency of the ground plane currents in larger devices (the impedance is easier to match). The increase saturates with relatively large antennas with good matching levels
- **1 to 2 dB total-efficiency difference between the 600-MHz band proposals at Tx frequencies**
- **1 to 4 dB total-efficiency difference at Tx frequencies between B17 antenna and B17 antenna tuned to 600-MHz bands**
- **Not much difference in total efficiencies between B17-to-600-MHz and 600-MHz-band-optimized antennas, but large differences in matching** because the matching cannot be properly optimized. Bad matching leads to load-pull problems with the power amplifier.